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MANEUVERING AEROTHERMAL TECHNOLOGY (MAT) PROGRAM

MAT PROGRAM TEST SUMMARY REPORT

BICONIC BODY WITH SLICE/FLAP

SCIENCE APPLICATIONS, INC.
APPLIED MECHANICS OPERATION
WAYNE, PENNSYLVANIA 19087

JANUARY 1982

FINAL REPORT FOR PERIOD 16 MAY 1980 - 15 FEBRUARY 1982

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AIR FORCE BALLISTIC MISSILE OFFICE
NORTON AIR FORCE BASE, CALIFORNIA 92409

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Detailed shock layer surveys, surface heat transfer and pressure, and force and moment data were obtained on sharp and blunted bicone models tested under laminar and turbulent boundary layer flow conditions. The objective of these tests is to obtain a basic body of data under hypersonic flow conditions, and under a variety of flow conditions and geometric parameters which would be useful for checking and validating the newly developed parabolized Navier-Stokes (PNS) codes, and other detailed flow field codes. Tests were conducted at the von Karman Facility (VKF) of the Arnold Engineering Development (over)

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Center (AEDC) in the Tunnels B and C at Mach numbers 6, 8, and 10. The model consisted of a 7° aft cone section to which forecones with half angles of 7°, 10.5°, and 14° were added. The aft cone section had a double slice cut into the windward side, and limited turbulent boundary layer data were obtained with a flap located at the juncture of the second slice. A roughness ring was used to promote turbulent boundary layer flow conditions for the blunted configurations. In general two categories of data were obtained, one with the model at a nominal room temperature (e.g., for the surface heat transfer, pressure, and force and moment) and the other with the model soaked to an equilibrium wall temperature, near adiabatic, wherein shock layer profiles were obtained. Measurements were made for several configurations, model attitudes, and Reynolds numbers.

This report presents a summary listing of all of the data obtained using this model, that is those data obtained at AEDC prior to the MAT program and also those data obtained under MAT program auspices. It makes no attempt to present the voluminous body of data obtained, per se, rather it is intended to provide the user with a collected detailed (including AEDC run numbers) listing of <u>all</u> of the data obtained including all pertinent test details and data reduction procedures inherent in the listings. Also included in this report are some limited data trends, highlights, and general observations as well as examples of data retrieved for code comparison purposes.

FOREWORD

This report presents the work performed for the Ballistic Missile Office (BMO) by Science Applications, Inc. (SAI) under the auspices of the Phase I part of the Maneuvering Aerothermal Technology (MAT) program (contract F04701-80-C-0033) for the period 16 May 1980 through 15 February 1982. This specific effort was accomplished under Task 2.3 (Experimental Studies) and was monitored by Capt. J. Keesee (BMO/SYDT) and D. Farlow (TRW/DSSG).

Contained in this report is a summary of all data obtained in the "HYTAC" sliced-bicone test series; that is those tests conducted by AEDC for BMO concluding with the tests run by SAI under the MAT program sponsorship.

The authors wish to acknowledge the following personnel of the von Karman Gas Dynamics Facility (VKF) of the Arnold Engineering Development Center (AEDC): D. B. Carver, S. M. Coulter, and D. L. Lanham for their assistance in the planning and conducting of the tests. The authors also wish to express their appreciation to J. T. Best (Aerodynamics Systems Division - USAF AEDC) for his assistance in the planning, scheduling, and cost maintenance of the test program.

This report has been reviewed and is approved.

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TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (CONT'D)

LIST OF FIGURES (CONT'D)

LIST OF FIGURES (CONT'D)

LIST OF TABLES

LIST OF TABLES (Cont'd)

NOMENCLATURE

ALPT	Pitch angle of the overhead probe drive (Z' direction) measured from the tunnel vertical axis
C	Flap chord length
CCTV	Closed Circuit television system
C_F	Skin friction coefficient, τ_w/q_∞
C_m	Pitching moment coefficient
C_N	Normal force coefficient
D	Diameter
DX	Computation step size
H,h	Boundary layer trip height
ℓ	Axial distance from bicone-slice juncture
M	Mach number
MACS	Model Attitude Control System
MAT	Maneuvering Aerothermal Technology Program
p	Pressure
PP	Pitot pressure
PT,P_O	Tunnel stilling chamber (total) pressure
PNS	Parabolized Navier Stokes flowfield code
q	Dynamic pressure
r	Radius
Re	Reynolds number
Re_O	Local Reynolds number with viscosity based on freestream total temperature
R_N	Nose radius
S	Curvilinear surface distance from model nosetip

NOMENCLATURE (CONT'D)

s	Flap semi-span
ST_∞ , ST(TT)	Stanton number based on freestream total temperature
T	Temperature
TG	Thermocouple gage
TT, T_o	Total temperature
TTL	Local total temperature
u	Velocity
X,Y,Z	Model axial, lateral and vertical coordinates
XF	Chordwise distance from flap leading edge
YF	Spanwise distance from flap centerline
Z'	Probe travel direction
ZP	Height of Pitot probe above model surface (Z' direction usually normal to the local surface unless otherwise specified)
α	Angle of attack
β	Angle of sideslip
γ	Specific heat ratio
δ	Flap deflection angle
δ^*	Boundary layer displacement thickness
δ_T	Thermal boundary layer thickness
δ_3	Boundary layer kinetic energy thickness
δ_4	Boundary layer total enthalpy thickness
η	Recovery factor
θ	Boundary layer momentum thickness

NOMENCLATURE (CONT'D)

θ_c	Cone half-angle
ρ	Density
τ_w	Shear stress at wall
ω	Meridian angle

SUBSCRIPTS

b	Body
c	Corrected
e	Boundary layer edge
L	Local
m	Measured
o,t	Total
REF	Reference
s	Shock
STAG	Stagnation point
W	Model wall
∞	Free-stream

TABULATED DATA KEY

A	Reference area, 75.784 in.^{2}
AATCA, α_T	Total pitch angle sensed by the Mach/Flow-Angularity probe, deg.
AB	Base area, 75.784 in.^{2} (no slices) or 69.912 in.^{2} (double slice)
ALPHA	Angle of attack deg
ALPHA SECTOR	Pitch angle of the tunnel sector, positive nose up, deg
ALPHAP	Model total angle of attack in the missile axis system, designated as positive for nose up attitude, deg
ALPI	Indicated pitch angle, deg
ALPO	Nominal pitch angle of the Mach/Flow-Angularity probe relative to the probe drive (Z' axis), positive nose up, deg
ALPP	Nominal pitch angle of the Mach/Flow-Angularity probe with respect to the vertical (Tunnel ZT axis), [ALPT + ALPO], deg
ALPT	Pitch angle that the overhead probe drive makes (Z' direction) with respect to the vertical (Tunnel ZT axis), deg
APP, AP(1 - 5), APRES, APPU, APW	Pressure stabilization routine slip flow coefficients for the Pitot tube, Mach/Flow-Angularity probe, Preston tube, upper Pitot, and surface pressure orifices, respectively, psia
AW	Speed of sound based on TW, ft/sec
BETA	Sideslip angle, deg
CA	Forebody axial-force coefficient, body axes, CAT-CAB
CAB	Base axial-force coefficient, body axes, -AB(PBA-P)/Q·A
CAT	Total axial-force coefficient, body axes, total axial force/Q·A

CCW	Cross-wind coefficient, wind axes
CDW	Forebody drag coefficient, wind axes
CFX	Skin friction coefficient, [TAUX/Q]
CLL	Rolling-moment coefficient, body axes, rolling moment/Q•A•LM
CLLW	Rolling-moment coefficient (based on CLMF), wind axes
CLM	Pitching-moment coefficient, body axes, pitching moment/Q•A•LM
CLMF	Forebody pitching-moment coefficient, body axes, CLM + CAB•ZB/LM
CLMW	Pitching-moment coefficient (based on CLMF), wind axes
CLN	Yawing-moment coefficient, body axes, yawing moment/Q•A•LM
CLNW	Yawing-moment coefficient, wind axes
CLW	Lift coefficient (based on CA), wind axes
CN	Normal-force coefficient, body axes, normal force/Q•A
CODE	Configuration code number
CONFIGURATION	Model configuration description (10.5/7-DEG BICONIC/SS + DS) where SS + DS = single slice and double slice
CPBA	Average base pressure coefficient, (PBA-P)/Q
CPHI	Local radial direction of the flow with respect to the Mach/Flow-Angularity probe, deg
C.R.	Center of rotation, axial station along the tunnel centerline about which the model rotates, in.
CY	Side-force coefficient, body axes, side force/Q•A
D	Preston tube outside diameter, ft

DCAT	Flap differential total axial-force coefficient, body axes, CAT(flap on) - CAT (flap off)
DCLL	Flap differential rolling-moment coefficient, body axes, CLL (flap on) - CLL (flap off)
DCLM	Flap differential pitching-moment coefficient, body axes, CLM (flap on) - CLM (flap off)
DCLMF	Flap differential forebody pitching-moment coefficient, body axes, CLMF (flap on) - CLMF (flap off)
DCLN	Flap differential yawing-moment coefficient, body axes, CLN (flap on) - CLN (flap off)
DCN	Flap differential normal-force coefficient, body axes, CN (flap on) - CN (flap off)
DCY	Flap differential side-force coefficient, body axes, CY (flap on) - CY (flap off)
DEL	Boundary-layer thickness, in.
DEL*	Boundary-layer displacement thickness, in.
DEL**	Boundar-layer momentum thickness, in.
DEL3	Boundary-layer kinetic energy thickness, in.
DEL4	Boundary-layer total enthalpy defect, in.
DEW	Free-stream flow frost point, ^{o}F
DITTE	Enthalpy difference at boundary-layer edge [ITTE - ITWX], Btu/lbm
DITTL	Local enthalpy difference [ITTL - ITWX], Btu/lbm
DPSQP	Mach/Flow-Angularity probe nondimensional parameter, $[(DP13)^2 + (DP24)^2]^{0.5}/(2 \cdot P5)$
DP13	Differential pressure measurement of the Mach/Flow-Angularity probe in the pitch plane [P1-P3], psid

DP24	Differential pressure measurement of the Mach/Flow-Angularity probe in the yaw plane [P2-P4], psid
DTAU	Preston tube data reduction iteration parameter, lb/ft^2
DY	Lateral movement of probe assembly during Preston tube surveys, referenced to the survey station number, same sign convention as YT, in.
ETA	Effective total-temperature probe recovery factor for calibration data:
	ETA = (TTLU - T)/(TT-T)
	For Survey data:
	$ETA = \sum_{i=0}^{1} A_i \sqrt{RETD}$
	where the values of A_i were determined for each thermocouple probe.
FLAP	Flap deflection angle with respect to model centerline, deg, positive down at PHI = 0
FRA	Preston tube data reduction parameter
FUN	Preston tube data reduction parameter
G	Preston tube data reduction parameter
$\dot{G}$	Preston tube data reduction parameter
GAGE NO	Identification number for Gardon gages
H(TT)	Heat-transfer coefficient, [QDOT/(TT-TW)], $Btu/ft^2\text{-sec-}^oR$
ITTE	Enthalpy of air based onTTE, Btu/lbm
ITT	Enthalpy of air based onTT, Btu/lbm
ITTL	Enthalpy of air based on TTL, Btu/lbm

ITW	Enthalpy of air based on TW, Btu/lbm
ITWX	Enthalpy of air based on TWX, Btu/lbm
KPP, KPPU, KPRES, KPW, KP (1-5)	Coefficients obtained by the pressure stabilization routine for Pitot pressure, upper Pitot pressure, Preston tube pressure, surface pressure Mach/Flow-Angularity pressures 1→5. 1/psi-sec
KNPP, KNPPU, KNPRES, KNPW, KNP (1-5)	Nominal stabilization coefficients, evaluated by an examination of the calculated coefficients defined above. 1/psi-sec
(L/D)W	Lift-to-drag ratio (based on CA), wind axes
LM	Model reference length, in.
M	Free-stream Mach number
ME	Mach number at boundary-layer edge (ML at DEL)
ML	Local Mach number, from Pitot pressure and wall pressure measurements
MLC	Local Mach number inferred by the Mach/Flow Angularity probe
MODEL-ROLL	Model roll angle, zero for single slice on top and positive for clockwise rotation, looking upstream, deg
MT	Preston tube data reduction parameter
MU	Dynamic viscosity based on free-stream temperature, $lbf\text{-}sec/ft^2$
MUTE	Dynamic viscosity based on TE, $lbf\text{-}sec/ft^2$
MUTL	Dynamic viscosity based on TL, $lbf\text{-}sec/ft^2$
MUW	Dynamic viscosity based on TW, $lbf\text{-}sec/ft^2$
MUTTL	Dynamic viscosity based on TTL, $lbf\text{-}sec/ft^2$
M2	Local Mach number, from Preston tube and wall pressure measurements

NCP	Normal-force center-of-pressure location, body axes, inches from model nose, XMRP-(CLM•LM/CN)
NOSE RADIUS, RN	Model nose radius, in.
OMEGA	Radial position of gages or orifices, deg
ORIFICE	Identification number of the pressure orifices
P	Free-stream static pressure, psia
PAVG	Average pressure value of the Mach/Flow-Angularity probe "static orifices" [(P1 + P2 + P3 + P4)/4], psia
PAVGP5	Ratio, PAVG/P5
PAVGP5C	PAVGP5 corrected for Reynolds number effects $\mathrm{PAVGP5C} = \dfrac{\mathrm{PAVGP5}_{RE\,=\,3.7}}{\mathrm{PAVGP5}_{REL}} \cdot \mathrm{PAVGP5}_{REL}$
PBA	Average base pressure, psia
PBI	Base pressure, i = 1 to 4, psia
PHI	Model roll angle, deg
PHII	Indicated roll angle, deg
PHIO	Roll alignment of the Mach/Flow Angularity probe with respect to the tunnel axis, zero for orifice P1 on top and positive for P1 rotated clockwise looking downstream, deg
PN	Data point number
PP, P(1-5), PPRES, PPU, PW	Pressure measurement for the Pitot tube, Mach/Flow Angularity pressures, Preston tube, upper Pitot, and surface pressures, respectively, psia
PP1, P(1-5)I, PPRES1, PPU1, PW1	First transducer measurement for the Pitot probe, Mach/Flow angularity pressures, Preston tube, upper Pitot, and surface pressures, respectively, psia

PPF, P(1-5)F PPRESF, PPUF, PWF	Final transducer measurement for the Pitot probe, Mach/Flow angularity pressures, Preston tube, upper Pitot, and surface pressures, respectively, psia
PPE	Pitot probe pressure at the boundary-layer edge (PP at ZP = DEL), psia
PPI	Pitot probe pressure interpolated to ZT, psia
PSIO	Yaw alignment of the Mach/Flow Angularity probe with respect to the tunnel axis, positive for the probe rotated counter-clockwise as viewed from above, deg
PT	Tunnel stilling chamber pressure, psia
PTAU	Preston tube data reduction parameter
PTM	Measured tunnel stilling chamber pressure, psia
PTP	Preston tube compressibility parameter
PT2	Free-stream total pressure downstream of a normal shock, psia
PW	Model surface pressure, psia
PWX	Model surface pressure at the location of the survey, psia
Q	Free-stream dynamic pressure, psia
QDOT	Heat-transfer rate at model surface, Btu/ft^2-sec
RE	Free-stream unit Reynolds number, ft^{-1}
REE	Unit Reynolds number at boundary-layer edge (REL at ZP = DEL), ft^{-1}
REL	Local unit Reynolds number, ft^{-1}
RETD	Local "normal shock" Reynolds number based on total temperature probe reference dimension and viscosity of MUTTL
RETTE	"Normal shock" unit Reynolds number at boundary-layer edge (RETTL at ZP = DEL), ft^{-1}

RETTL	Local "normal shock" unit Reynolds number (based on viscosity of MUTTL), ft^{-1}
RHO	Free-stream density, lbm/ft^3
RHOE	Density at boundary-layer edge (RHOL at ZP = DEL), lbm/ft^3
RHOL	Local density, lbm/ft^3
RHOUE	Product of RHOE and UE, $lbm/sec\text{-}ft^2$
RHOW	Density based on TW, lbm/ft^3
RN	Model nose radius, in.
RT	Preston tube data reduction parameter
RUN	Data set identification number
R2D	Local Reynolds number, based on Preston tube diameter
S	Curvilinear surface distance from model nosetip, in.
SLICES	Number of slices on bottom, aft portion of the model
ST(TT)	Stanton number based on TT, $$ST(TT) = \frac{QDOT}{(RHO)\ (V)\ (ITT\text{-}ITW)}$$
SURVEY STATION NO	Location of the survey, corresponds to the pressure orifice number above which the survey began
T	Free-stream static temperature, ^oR
TAUX	Wall shear stress (Preston tube), lb/ft^2
TDEL	Delay time between data initiation and start of data recording, sec
TE	Static temperature of boundary-layer edge (TL at ZP = DEL), ^oR

TG_i	Model surface temperature corresponding to coax gage "i", ^oR
THETAO	Pitch alignment of the Mach/Flow-Angularity probe with respect to the tunnel axis system, positive for probe tip rotated up, deg
TL	Local static temperature, ^oR
TNPP, TNP(1-5), TNPRES, TNPPU, TNPW	Nominal time constant for the Pitot probe, Mach/Flow Angularity probe, Preston tube, upper Pitot probe, and surface pressure measurement, respectively, seconds e.g., $TNPP = \dfrac{1}{KNPP(2 \cdot PPF + APP)}$, sec
TREC	Elapsed time to record 40 samples of pressure history for pressure stabilization routine, seconds
TRIP	Boundary-layer trip identification
TT	Tunnel stilling chamber temperature, ^oR
TTE	Total temperature at boundary-layer edge (TTL at ZP = DEL), ^oR
TTL	Local total temperature, measured by an unshielded thermocouple probe and corrected for Reynolds number effects, ^oR
TTLI	Local total temperature interpolated to ZP, ^oR
TTLU	Uncorrected (measured) probe total temperature, ^oR
TW	Gardon or coax gage surface temperature, ^oR
TWX	Temperature of coax gage nearest the survey station, ^oR
UE	Local velocity component parallel to model surface at boundary-layer edge (UL at ZP = DEL), ft/sec

UF, VF, WF	Local velocity vector components with respect to the tunnel axis system, ft/sec
UL	Local velocity parallel to the model surface: computed from Pitot pressure, wall static pressure and total temperature measurements, considered valid near the model (boundary layer region), ft/sec
UM, VM, WM	Local velocity vector components with respect to the model axis system, ft/sec
UP, VP, WP	Local velocity vector components with respect to the Mach/Flow-Angularity probe, ft/sec
U2	Local velocity computed from Preston tube pressure, wall static pressure and wall surface temperature measurements, ft/sec
V	Free-stream velocity, ft/sec
VL	Local total velocity at the Mach/Flow Angularity probe, ft/sec
X, Y, Z	Model instrumentation locations
XF, YF	Flap instrumentation locations
XMRP	Axial distance from model moment reference point to model virtual apex, in.
XT	Axial distance from model moment reference point to balance momement reference point, in.
XT, YT , ZT	Orthogonal tunnel axis system coo dinates, tabulated values are nominal location of the probe during calibrations, in.
YCP	Side-force center-of-pressure location, body axes, inches from model nose, XMRP-(CLN·LM/CY)
ZB	Vertical distance from the model x-axis to the centroid of the base area, positive if the centroid is below the x-axis at PHI = 0, 0 (no slices) or -0.348 in. (double slice)

ZM	Height of Mach/Flow-Angularity probe above model surface along a normal line, in.
ZP	Height of Pitot probe above model surface along a normal line, in.
ZPU	Height of upper Pitot probe above model surface along a normal line, in.
ZT	Height of total temperature probe above model surface along a normal line, in.
Z'	Direction of the probe travel along the Z' Drive Shaft

1.0 INTRODUCTION

Within the last decade significant advances have been made in computer architecture and in the complementary development of large scale computer programs for solving complex non-linear problems. In the field of fluid dynamics, computer programs have been developed to provide detailed properties of the flow field surrounding complex aerodynamic configurations. In addition, during this past decade, energy costs have risen so dramatically that the 'customary' use of the wind tunnel as a vehicle-configuration design aid has diminished significantly. As a result, a suitable combination of numerically generated configuration aerodynamics with experimentally generated results can lead to the desired solution in an efficient and cost effective manner.

Recognizing the advances that were being made in computational fluid dynamics, the Air Force structured the Maneuvering Aerothermal Technology (MAT) program to assess and improve the currently available technology for predicting MaRV aerothermal performance for current and next generation vehicles in flight regimes characteristic of future mission requirements. The types of computer codes that were to be evaluated in this contract ranged from the empirical methods (such as the Hypersonic Arbitrary Body Program (HABP) and the Aerodynamic Heating Program (AERHEAT)) which contain the technologies of the 60's, to the more current "sophisticated" large scale programs which numerically solve various simplified versions of the Navier Stokes equations. These include the inviscid flow field solutions, boundary layer solutions, and the more recent parbolized Navier Stokes (PNS) computer solutions.

These large scale computer codes, like newly developed wind tunnels, require a detailed "shake down" to resolve developmental difficulties in logic, numerics, grid resolution, turbulence modeling, etc. To accomplish a complete check-out of these programs, detailed "bench-mark" experimental data are required with which to resolve their predictive capabilities. The current set

of experimental data were obtained with this objective in mind. However one must recognize that the predictive ability and accuracy of any aerodynamic computer code is dependent on the vehicle configuration. Thus one must first establish systems requirements and performance goals, then consistent with these, establish the generic vehicle configuration(s) that are required to meet these requirements and goals. The MAT program has provided both the systems requirements and performance goals. The current set of experimental data satisfy one aspect of these overall objectives. Specifically, flow field data were obtained on sharp and blunt axisymmetric biconic configurations under laminar and turbulent boundary layer flow conditions over a range of hypersonic Mach Numbers and angles of attack. In addition data were also obtained on the aft section of the bicone where a slice cut was taken and where a flap was placed. This type of configuration represents one type of maneuvering reentry vehicle (MaRV) of specific interest to the Air Force. The types of data obtained are configuration force and moment, surface pressure, shear, heat transfer, and flow field surveys including pitot pressure, total temperature, and flow angularity. The force and moment data provide the resultant checkout accuracy of all of the computer codes-empirical or 'exact'. However to provide additional diagnostic detail when agreement with these data is less than satisfactory, is the specific role of the detailed data-surface and flow-field measurements. The shock layer surveys are an especially useful diagnostic tool in regions of the configuration where sudden expansions or compressions are present. For these reasons, in the current test series, the shock layer surveys were concentrated in the slice/flap regions of the vehicle along with sufficient upstream measurements on the axisymmetric surfaces to provide the 'bench-mark' reference.

This report summarized and catalogs the entire body of data obtained on the biconic configurations in the AEDC-VKF Tunnels B and C at Mach numbers of 6, 8, and 10. The test specifically sponsored by the MAT program corresponds to the Mach 8 turbulent boundary layer

experimental on the 10.5^{o}/7^{o} sliced bicone with flap. The remainder of the experiments referred to in this report were conducted by AEDC personnel under BMO sponsorship and Aerospace/TRW guidance. This report also provides some particulars of the data reduction details, provides typical results and limited data trends, highlights, and observations. Lastly, it contains illustrative examples of data extraction for code validation and check-out.

2.0 APPARATUS

2.1 Test Facilities

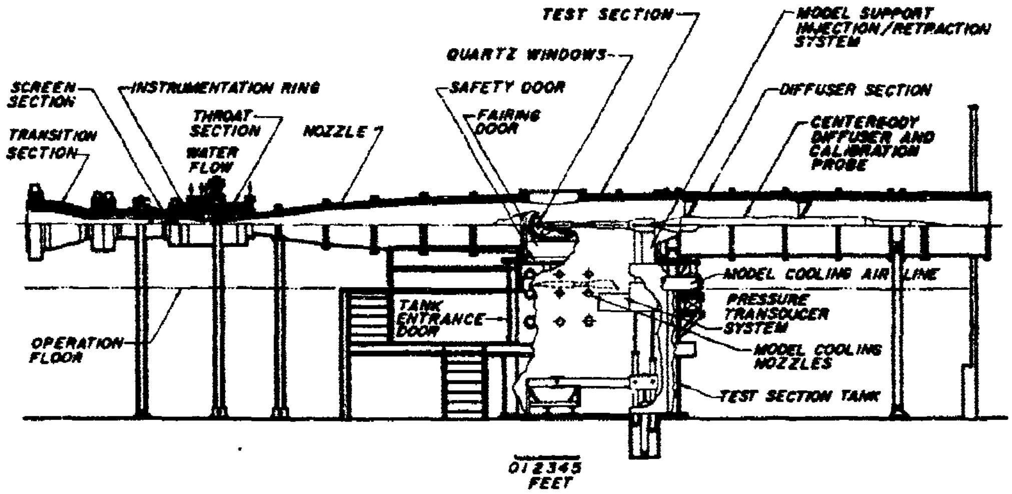
The tests were conducted in the hypersonic flow tunnels of the von Karman Facility at the Arnold Engineering Development Center; Tunnel B for Mach 6 and 8 and Tunnel C for Mach 10. Nominal tunnel performance characteristics are presented in Table 1.

TABLE 1. TUNNELS B AND C PERFORMANCE

Tunnel	Nominal Mach Number	p_0, psia		T_0, °F	q, psia		Re/ft x 10^{-6}	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.
B	6	20	270	390	0.3	4.1	0.3	4.7
	8	50	850	890	0.3	3.8	0.3	3.7
C	10	200	2000	1450	0.3	3.0	0.3	2.4

Both tunnels are closed circuit with axisymmetric contoured nozzles with a 50 inch diameter test section and operate continually over a range of pressure levels with air supplied by the main compressor system. Stagnation temperatures sufficient to avoid liquefaction in the test section are obtained through the use of a natural-gas-fired combustion heater in combination with the compressor heat of compression at Mach 6 and 8 and in combination with electric resistance heaters at Mach 10. Each entire tunnel (throat, nozzle, test section, and diffuser) is cooled by integral, external water jackets. Both tunnels have identical test sections equipped with model injection systems.

Directly below each test section is a tank (Figure 1) into which the model and its support can be retracted. The test section can be sealed from its tank so that the tunnel can remain running while the tank is vented to atmospheric pressure in order that personnel may enter the tank to make modifications to the model or its support system. After the desired modifications are made and the tank entrance door is closed, the tank is vented



a. Tunnel Assembly

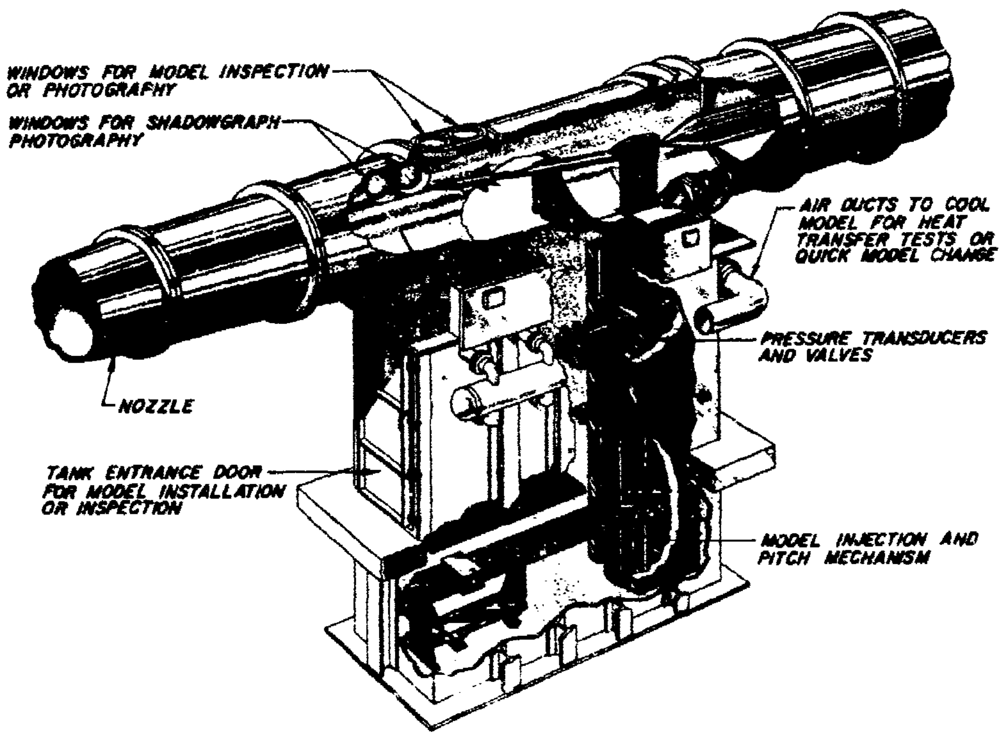


FIGURE 1. TUNNEL LAYOUT

to the test section pressure, the doors between the tank and test section are opened, and the model is injected into the airstream to obtain the desired data. Upon completion of the data acquisition, the model is retracted and the cycle completed. The injection system is also used for transient heat-transfer tests in which the model is cooled in the retracted position, set at the desired attitude, and injected into the airstream to obtain the time history of the temperatures at various locations on the model. The minimum injection time is about two seconds and the maximum acceleration or deceleration is about one g. The model is exposed to the airstream approximately 0.9 sec. prior to the injection stroke limit with the model in test position.

2.2 Model Detail

The model used for this investigation was comprised of several sections which permitted the testing of a sharp and blunt 7^{o} cone, and sharp and blunt bicones with 10.5^{o} and 14^{o} forecones. All components were fabricated from type 304 stainless steel. In addition the common 7^{o} half cone aft frustum was also sectioned to permit the inclusion of a slice/flap region. In order to provide a turbulent boundary layer for the blunted configurations, a ring of roughness trips were employed. Contained in the following sections is a detailed description of the model geometries used in this investigation including the trip geometry and the location of the surface instrumentation.

2.2.1 Basic Body

The test model used in this investigation is modular in concept, from which several bicone geometries, sharp and blunt, were assembled. The basic model components are shown in Figure 2. Exclusive of the sharp or blunt nose sections, the remainder of the model is comprised of three sections, the forecone section with half angles of 7^{o}, 10.5^{o}, and 14^{o}, and the two 7^{o} aft cone sections. For each bicone configuration, a sharp

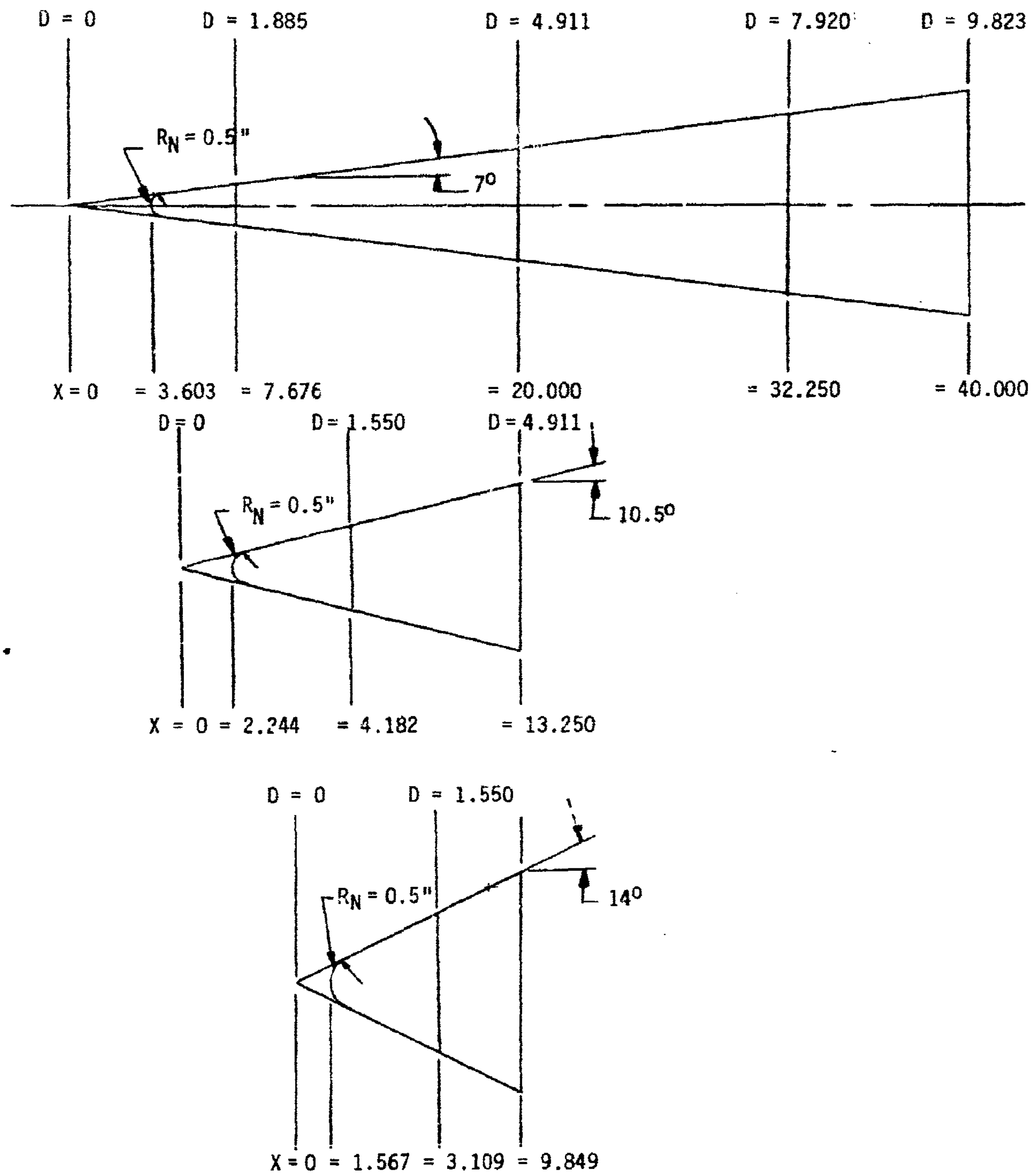


FIGURE 2. BASIC MODEL GEOMETRY

and a 0.50" R_N nosetip was tested. In summary, for this basic test series the following axisymmetric bicone configurations were tested.

Nose-R_N	Forecone	Aftcone	Model Length
0(.0015")	7^0	7^0	39.989
0.50"	7^0	7^0	36.397
0	10.5^0	7^0	33.250
0.50"	10.5^0	7^0	31.006
0	14^0	7^0	29.849
0.50"	14^0	7^0	28.282

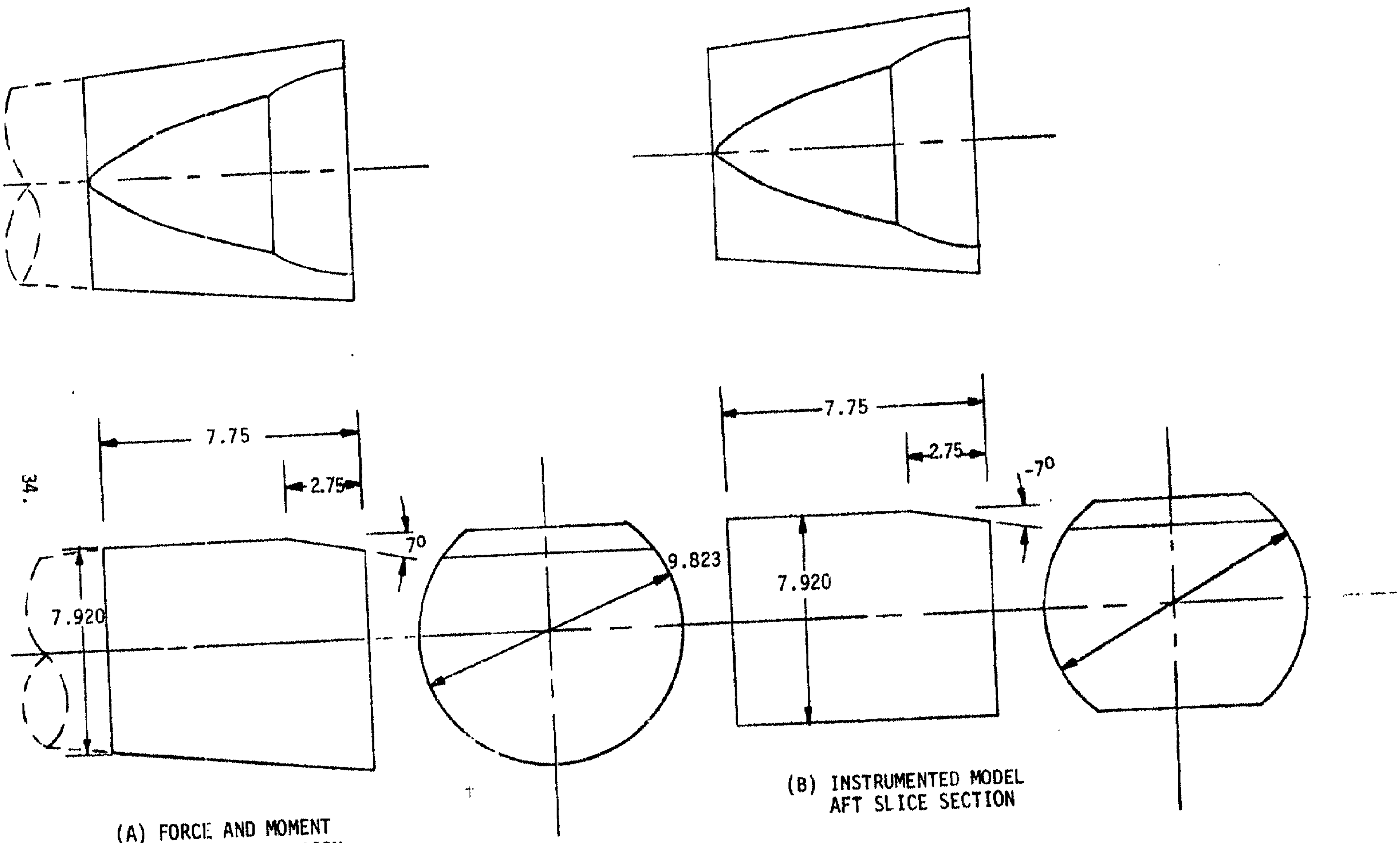
2.2.2 Slice Region

In addition to the aft 7^0 conical frustum section, two additional aft sections were fabricated. One section had a double windward slice as shown in Figure 3. The first slice is parallel to the axis and starts 7.75 inches upstream of the base. The second slice on this section is inclined 7^0 downward, 2.75 inches upstream of the model base. This aft section was used for the force and moment test series.

The other aft cone section had an identical windward side series of slices; however, in addition it also had a single parallel slice on the leeward side as shown in Figure 3. This aft section was used for the remainder of the test series; that is the pressure, heat transfer, and shock layer profiles

2.2.3 Flap

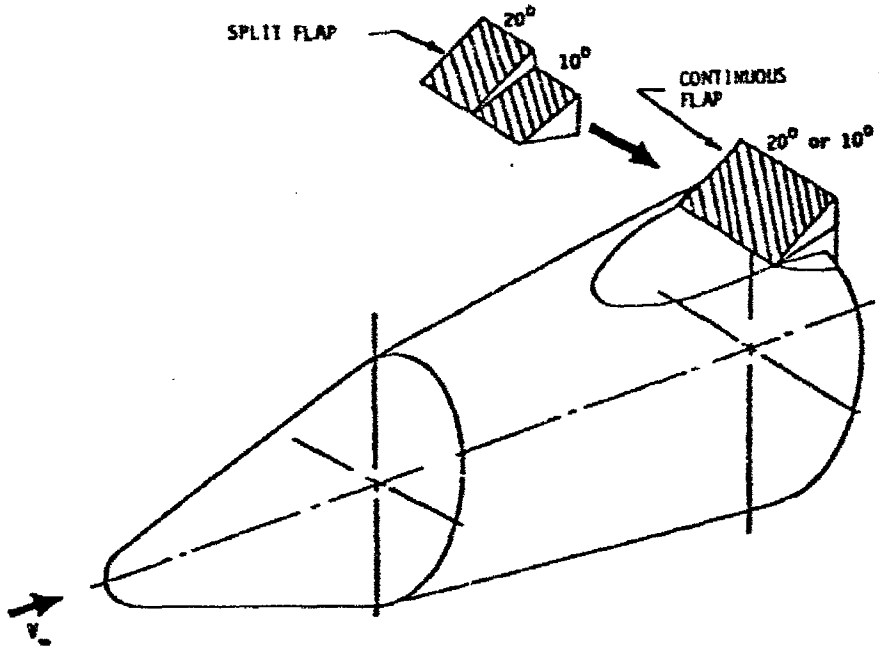
Under MAT program sponsorship, a series of flaps were fabricated for use with the aft slice sections. Three were built, a 10^0 and 20^0 continuous span flap and a split $20^0/10^0$ flap as shown in Figure 4. The hinge line of the flaps were located at the juncture of the second windward cut,



(A) FORCE AND MOMENT AFT SLICE SECTION

(B) INSTRUMENTED MODEL AFT SLICE SECTION

FIGURE 3. AFT SLICE SECTIONS



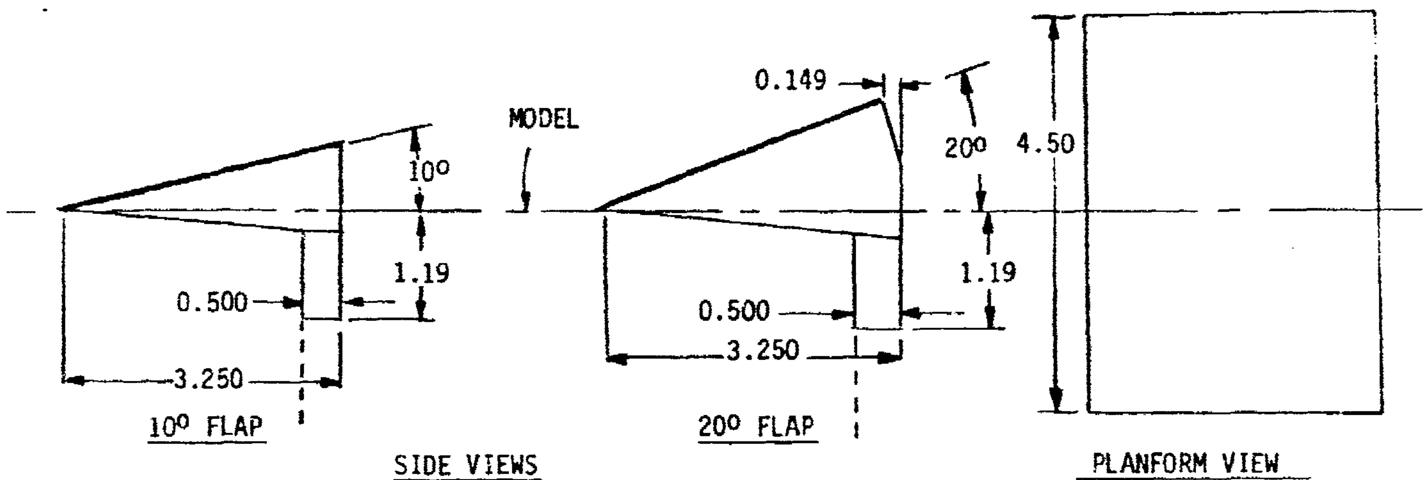


FIGURE 4. FLAP DETAILS

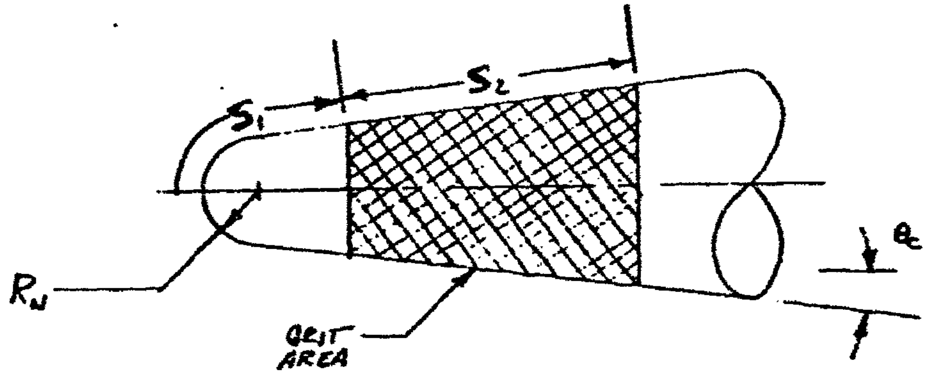
2.75 inches upstream of the base. For simplicity of installation the flaps were manufactured with a 0.50 inch overhang from the base and were attached to the basic body by fasteners into the base.

2.2.4 Roughness/Boundary Layer Trips

In the course of these experimental investigations, several test series were conducted for the primary prupose of determining the trip size - for a given model bluntness and test facility - which would provide a turbulent boundary layer (hopefully with the absence of inviscid flow disturbances). These investigations were primarily performed using the model surface heat transfer (cold wall) as the diagnostic for determining the departure from laminar flow. However, in certain cases investigations were also performed using the boundary layer portion of the shock layer survey as the diagnostic (i.e., for the hot wall case). Although the trip size, geometry, and relative placement on the models were similar, these parameters varied for several of the test series. Rather than summarize the pot-pourri of trips used, they are shown in Figures 5 and 6 for the Mach 6 and Mach 8 investigations, respectively.

The boundary layer trips consisted of distributed roughness formed by attaching Carborundum grit to the model surface, or by machining helical grooves in a spiral fashion (clockwise and counter clockwise) on the conical frustum part of the nose, or by blasting the metal surface with grit until the desired roughness was attained. The test data summarized in the following sections of this report will refer specifically to the trip used from Figures 5 and 6.

The turbulent boundary layer shock layer survey tests were performed using the machined roughness trips defined in Figure 6a and shown photographically in Figure 7.

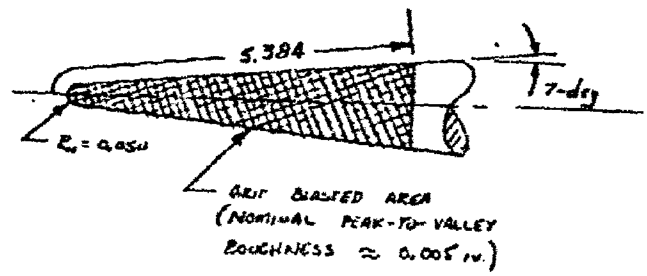


θ_c(DEG)	R_N (IN)	S_1 (IN)	S_2 (IN)	GRIT NO.	NOMINAL GRIT SIZE (IN)
7	0.05	1.481	3.900	60	0.010
	↓	↓	↓	30	0.022
	0.10	1.552	3.500	46	0.014
	0.50	1.574	0.800	80	0.0065
				60	0.010
				46	0.014
				30	0.022
↓	↓	↓	↓	20	0.037
10.5	0.05	1.352	2.700	60	0.010
	0.50	0.949	1.300	60	0.010
↓	↓	↓	↓	30	0.022
14	0.05	1.069	2.000	60	0.010
	0.50	0.661	1.200	100	0.0048
				80	0.0065
↓	↓	↓	↓	46	0.014

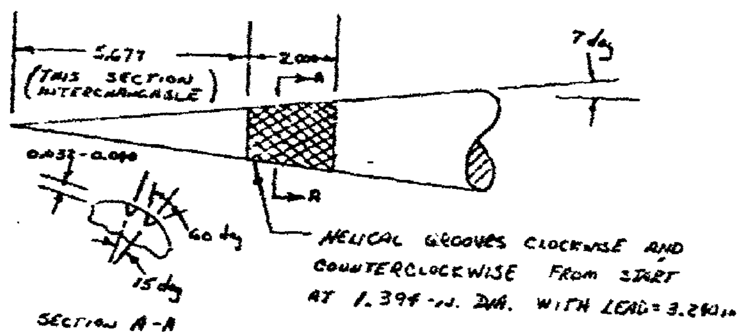
a. DISTRIBUTED GRIT TRIP

FIGURE 5. BOUNDARY LAYER TRIP GEOMETRY

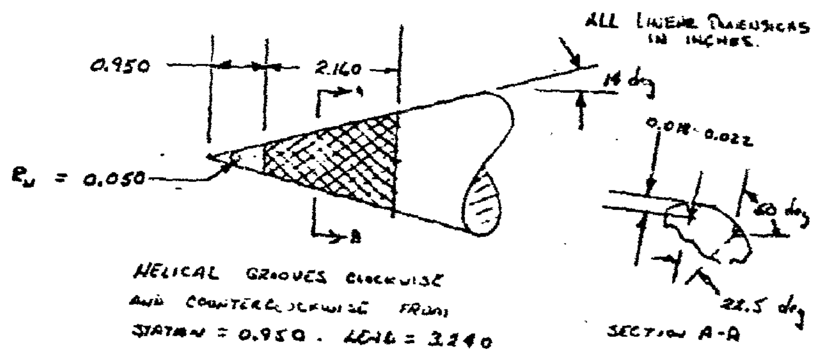
$[M_\infty = 6, \quad \alpha = 0^{o}]$



b. 7-deg grit blasted nose



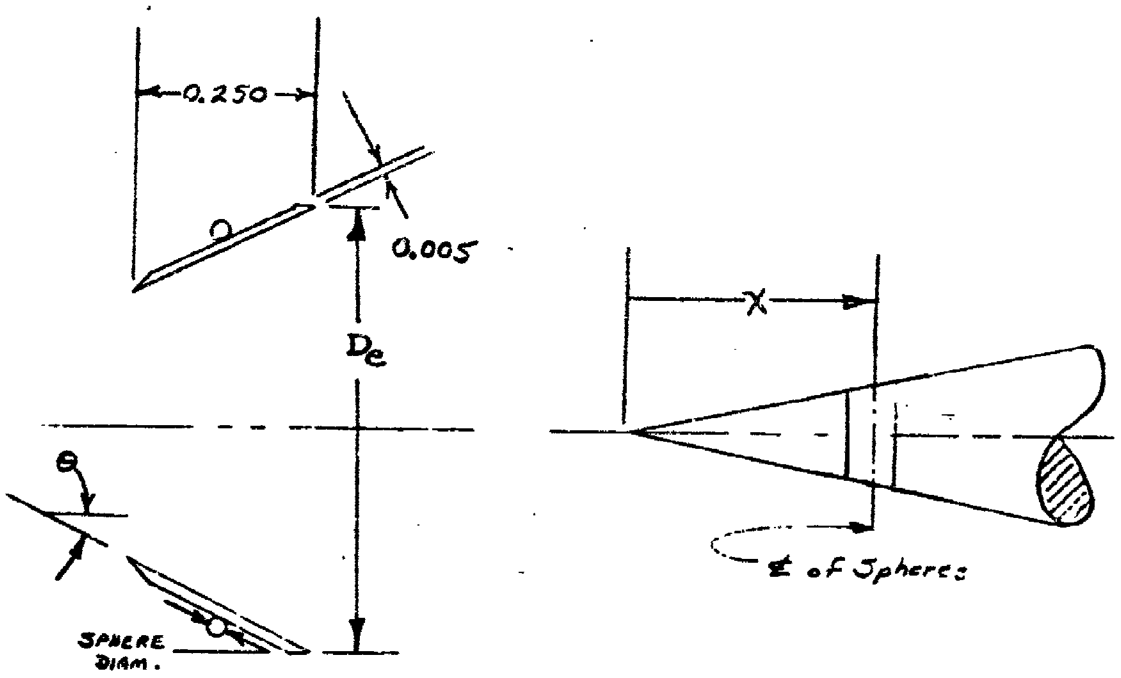
c. Grooved 7-deg insert



d. Grooved 14-deg nose

FIGURE 5. BOUNDARY LAYER TRIP GEOMETRY (CONT'D)

$[M_\infty = 6, \alpha = 0]$

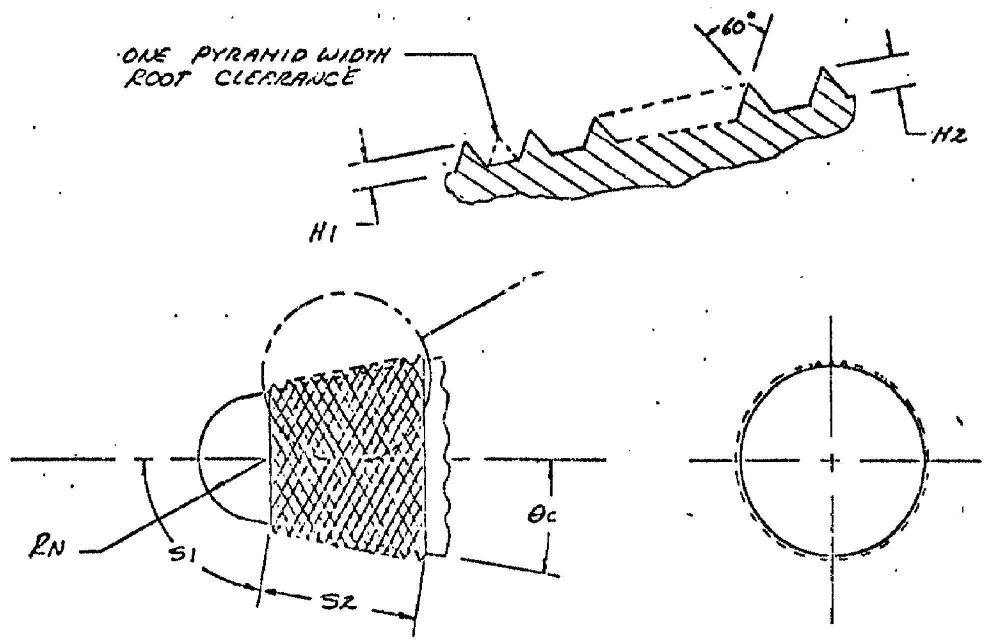


θ DEG.	X IN.	D_e IN.	SPHERE DIAM., IN.	NO. OF SPHERES
7	6.5	1.504	0.093	17
10.5	4.0	1.530	0.046	35
10.5	4.0	1.530	0.125	13
14	3.0	1.558	0.046	35
14	3.0	1.558	0.093	18

e. SPHERICAL ELEMENT TRIPS

FIGURE 5. BOUNDARY LAYER TRIP GEOMETRY (CONCLUDED)

[$M_\infty = 6, \alpha = 0$]



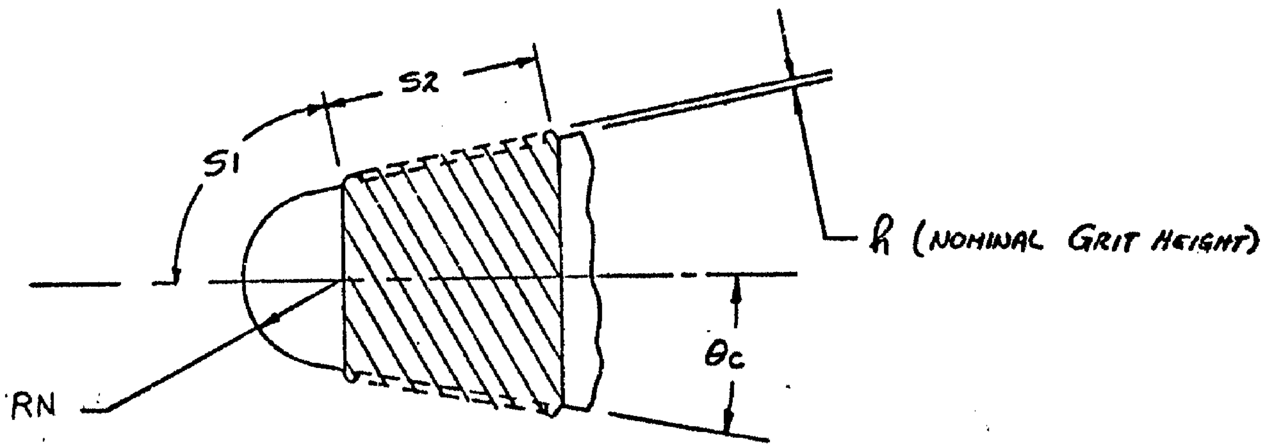
θ_c DEG.	R_N IN.	S_1 IN.	S_2 IN.	H_1 IN.	H_2* IN.
7	0.0015	5.760	1.914	0.031	0.060
7	0.500	2.422	1.914	0.031	0.060
10.5	0.500	0.949	1.249	0.006	0.013
↓	↓	↓	↓	0.015	0.033
↓	↓	↓	↓	0.024	0.060

*DIMENSION USED IN TABULATED DATA FOR IDENTIFICATION

a. MACHINED TRIPS

FIGURE 6. BOUNDARY LAYER TRIP GEOMETRY

$M_\infty = 8, \quad \alpha \neq 0$



TRIP NO.	θ_c (DEG)	R_N (IN)	S1 (IN)	S2 (IN)	h (IN)
5	10.5	0.500	0.949	1.249	0.037
6	14.0	0.500	0.661	1.149	0.028

b. Grit Bonded Trips

FIGURE 6. BOUNDARY LAYER TRIP GEOMETRY (CONT'D) $[M_\infty = 8, \alpha \neq 0]$

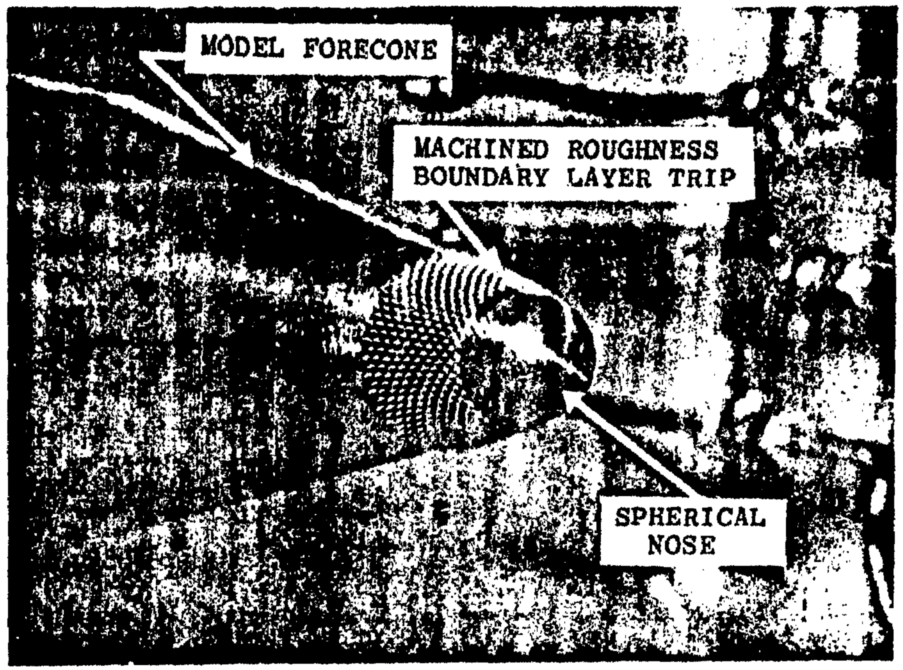


FIGURE 7. PHOTOGRAPH OF THE MACHINED BOUNDARY LAYER TRIP $[M_\infty = 8,\ \alpha \neq 0]$

2.2.5 Instrumentation

As indicated earlier, the measurements in this test series included total model static force, surface heat transfer, pressure and temperature, and also shock layer surveys (which included Pitot pressure, total temperature, Preston tube, and Mach/Flow Angularity measurements). Contained below is a summary discussion of the model surface instrumentation and locations, and the balance used for forces and moment definition. The material that is summarized below is excerpted from the appropriate AEDC Test Summary Reports (TSRs) and will be so referenced.

Model flow-field photographs were obtained with a single-pass optical flow visualization system through the two 17.25 inch diameter test sections windows.

2.2.5.1 Static Force

Static force measurements are provided using either point-pause or continuous sweep techniques. In the more conventional point-pause technique, the model support mechanism is moved to the desired model angle and stopped, measurements are taken, and then the sequence is repeated by moving to the next desired angle. In the continuous sweep technique the model is continuously varied in angle while measurements are taken, at rates of 0.5 deg/sec in pitch and 2 deg/sec in roll.

Forces and moments on models are measured with a six-component internal strain-gage balances using conventional foil and semiconductor gages. Balance details are described in Reference 1. The balance is temperature compensated over the range from 80 to 180^{0}F. Two copper-constantan thermocouples are provided for monitoring balance temperature.

The measuring and recording devices, and the calibration methods used for all measured parameters along with the estimated measured uncertainties are provided in Reference 2 for the Mach 10 laminar static force tests and in Reference 3 for the Mach 8 turbulent tests. Model base pressure was measured in the point - pause mode of operation with the VKF standard pressure system which uses 1-psid variable capacitance transducers referenced to near vacuum.

A photograph of the model mounted for the static force series shown in the dump tank below Tunnel B is presented in Figure 8. The machined trip ring device is readily seen in this photograph. Figure 9 portrays the model assembly in the Tunnel B test section.

2.2.5.2 Model Surface Instrumentation

Surface mounted instrumentation consisted of Gardon gages, coaxial thermocouple gages, and pressure orifices. The tests were conducted in several separate entries where the model configuration varied per entry, consequently the surface instrumentation also varied. The reference for each data set and the configuration tested is listed below.

Reference	Data Set	Models
4	Mach 6, $\alpha = 0$ (Turbulent)	7^o Cone $14^o/7^o$ Bicone
5	Mach 6, $\alpha = 0$ (Turbulent)	7^o Cone $10.5^o/7^o$ Bicone $14^o/7^o$ Bicone
6	Mach 8, $\alpha \neq 0$ (Turbulent)	7^o Cone $10.5^o/7^o$ Bicone $14^o/7^o$ Bicone
7	Mach 10, $\alpha \neq 0$ (Laminar)	$14^o/7^o$ Bicone w/Slices
8	Mach 8, $\alpha \neq 0$ (Turbulent)	$10.5^o/7^o$ Bicone w/Slice and Flap

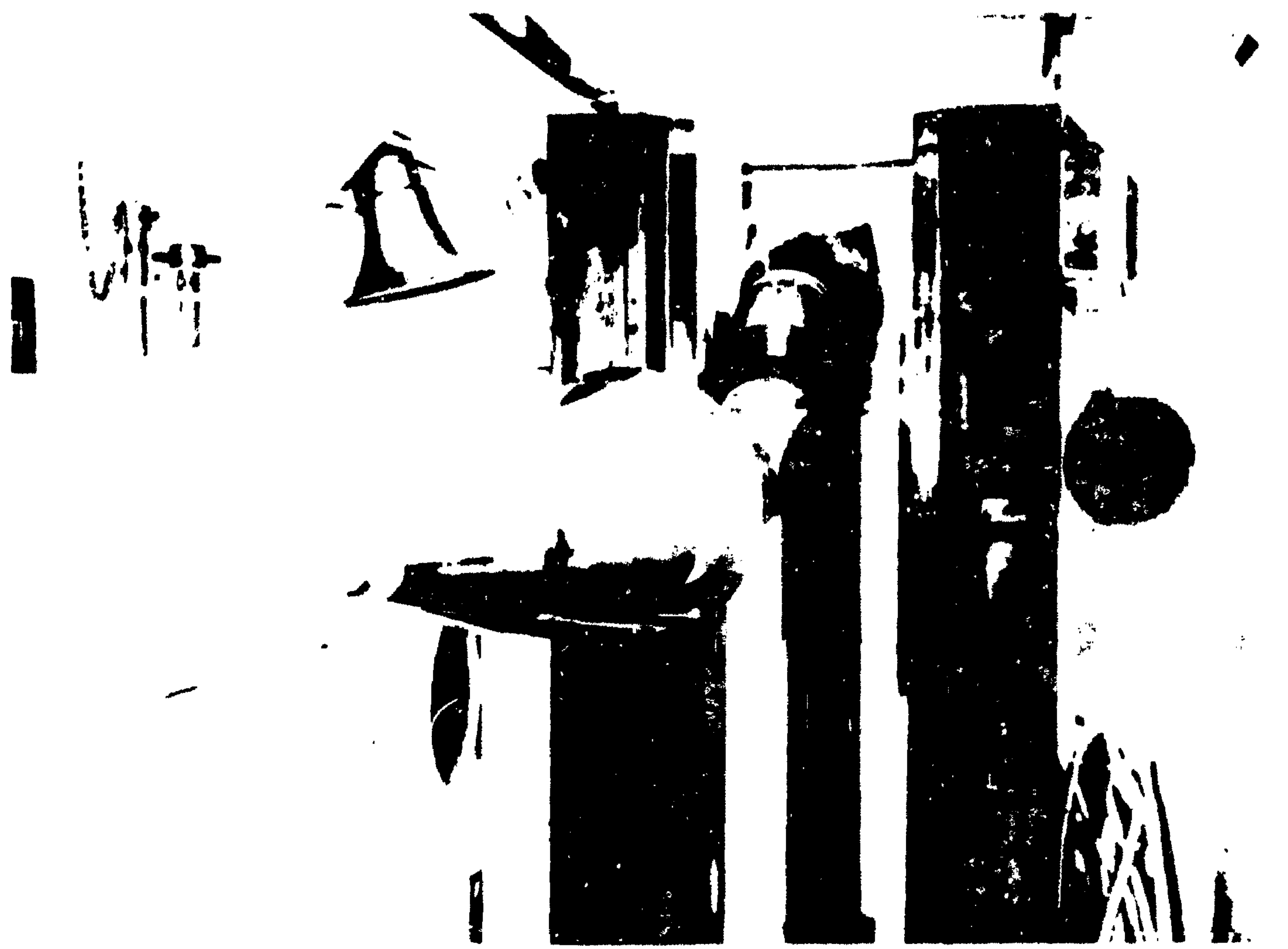


FIGURE 8. PHOTOGRAPH OF THE BICONE MODEL STATIC FORCE INSTALLATION VIEWED IN THE DUMP TANK BELOW TUNNEL B

4975 (7-20-81) V42B-215 BMO/SAI MAT-1 FORCE

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the Air Force Office of Public Affairs.

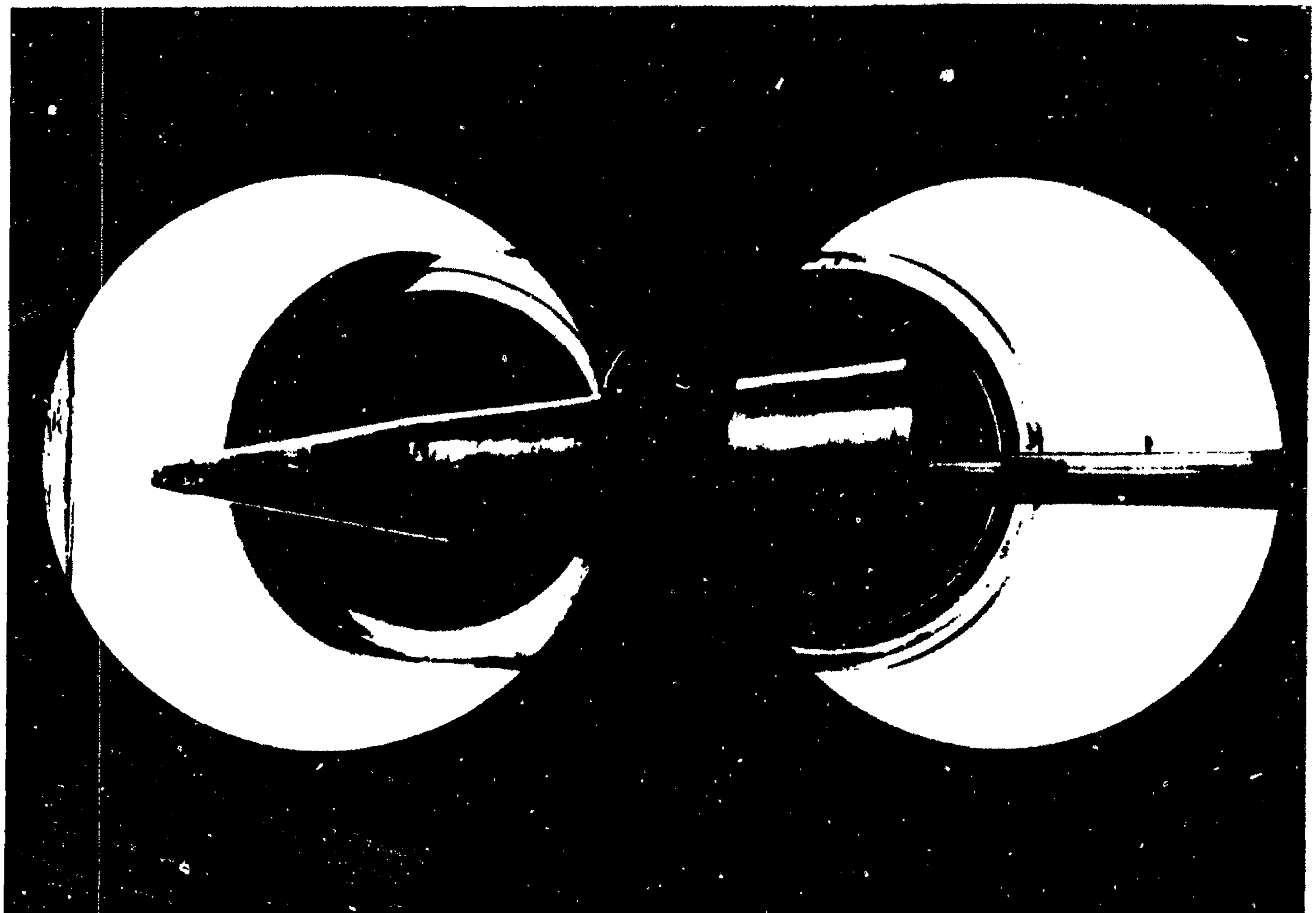


FIGURE 9. PHOTOGRAPH OF THE BICONE MODEL STATIC FORCE INSTALLATION IN TUNNEL B

4976 (7-20-81) V42B-215 BMO/SAI MAT-1 FORCE

Heat transfer data were obtained using 0.125 inch diameter Gardon-type heat flux gages with Iron-Constantan[R] case thermocouples. For the Mach 6 tests where the tunnel stagnation temperature is relatively low, it was possible to use the Gardon-gage not only as a transient gage for measuring heat transfer in the pulse entry mode, but it could also be used in the steady state-long time entry (i.e., for profile measurement) mode. The case thermocouple served a dual role by providing a sensing disc edge temperature used in the evaluation of the heat-transfer coefficient and by indicating the model wall temperature during the long hot-wall runs. As an additional check on the long term wall temperature coaxial surface thermocouples were used.

In the Mach 8 and 10 tests where the tunnel stagnation temperature is significantly higher and where the Gardon-type gages would not survive a long time entry, the model was only instrumented with this type gage for short duration heat transfer tests. Prior to the survey tests, the Gardon gages were removed and the holes were plugged or replaced by coaxial gages and the afterbody was replaced with a pressure instrumented afterbody. The pressure orifices in the afterbody were located at the same locations as the Gardon gages. The coaxial gages (surface thermocouples) were added for the survey tests to provide model surface temperature. Details of both types of gages may be found in Reference 9.

Three flap assemblies were used: heat transfer, full span pressure, and split pressure as depicted in Figure 4. The heat transfer flap was a full span adjustable deflection flap instrumented with nine Gardon gages. The full span pressure flap was essentially the same as the heat transfer flap except for instrumentation. The split pressure flap had fixed deflection angles of 10 and 20-deg for its two sides and was instrumented with seven orifices and two coaxial surface thermocouples. Specific gage and orifice locations are presented in Reference 8 and Section 3.4

It should be noted that in all cases the model was instrumented with more than 75 Gardon-type gages, and more than 80 pressure orifices so that a relatively complete surface coverage was obtained. The reader is referred to Section 3 or the specific test report for detail definition and locations of the surface instrumentation.

2.3 Flow Field Survey Probes and Probe System

Two separate probing systems were used to perform the boundary layer and flow field surveys. An overhead probe system which was the primary flow field survey mechanism was instrumented with a pitot tube, unshielded thermocouple probe and a Preston tube. A second system which was used with the axisymmetric bicones was attached to the model support sting and was equipped with a Pitot tube and an unshielded thermocouple probe. A Preston tube was included on the on-board probe installation, but pressure response from this probe was not satisfactory and data from this probe are not valid.

The axial, X, lateral, Y, and vertical, Z, overhead probe drive system, is used to survey flow fields in Tunnels B and C. The positioning mechanism is mounted above a port on the top of the tunnel. The X-Y-Z mechanism has five degrees of freedom: X, Y, Z, Z' and ALPT. In addition to the X, Y, and Z controls, this mechanism has the capability for inclining the probe head by an angle ALPT relative to a vertical (from the Z axis), and then probing in the Z' direction along this tilted vertical axis. Precision surveys along the Z' axis can repeatably be made to within $\pm$ 0.005 inches. Positioning of the probe holder attachment is arbitrary in the sense that no preprogramming is required and the mechanism moves independently of the model. All stations to be sampled must remain within the mechanism traversing envelope. Shown in Figures 10 to 12 are photographs of the probe housing assembly and of the probe holder assembly. Figure 13 is a photograph of the probe holder assembly shown in proximity to the model. The flattened Pitot, upper Pitot, total temperature and Preston tube probes were mounted in one probe holder, while the Mach/Flow-

FIGURE 10. PHOTOGRAPH OF THE PROBE HOUSING ASSEMBLY WITH THE PROBE ASSEMBLY ATTACHED

FIGURE 11. PHOTOGRAPH OF THE PROBE ASSEMBLY

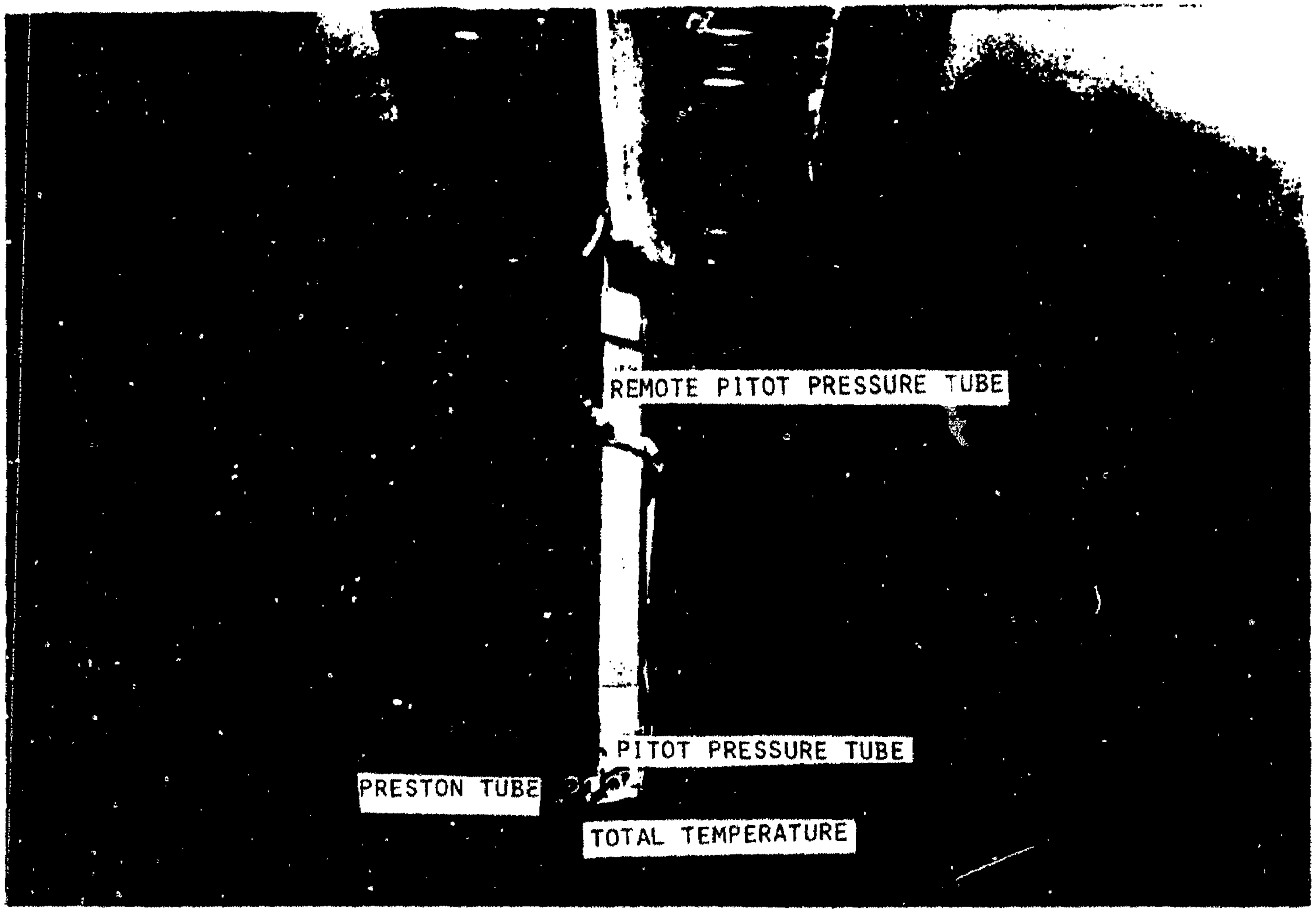


FIGURE 12. CLOSE-UP PHOTOGRAPH OF THE PROBE ASSEMBLY

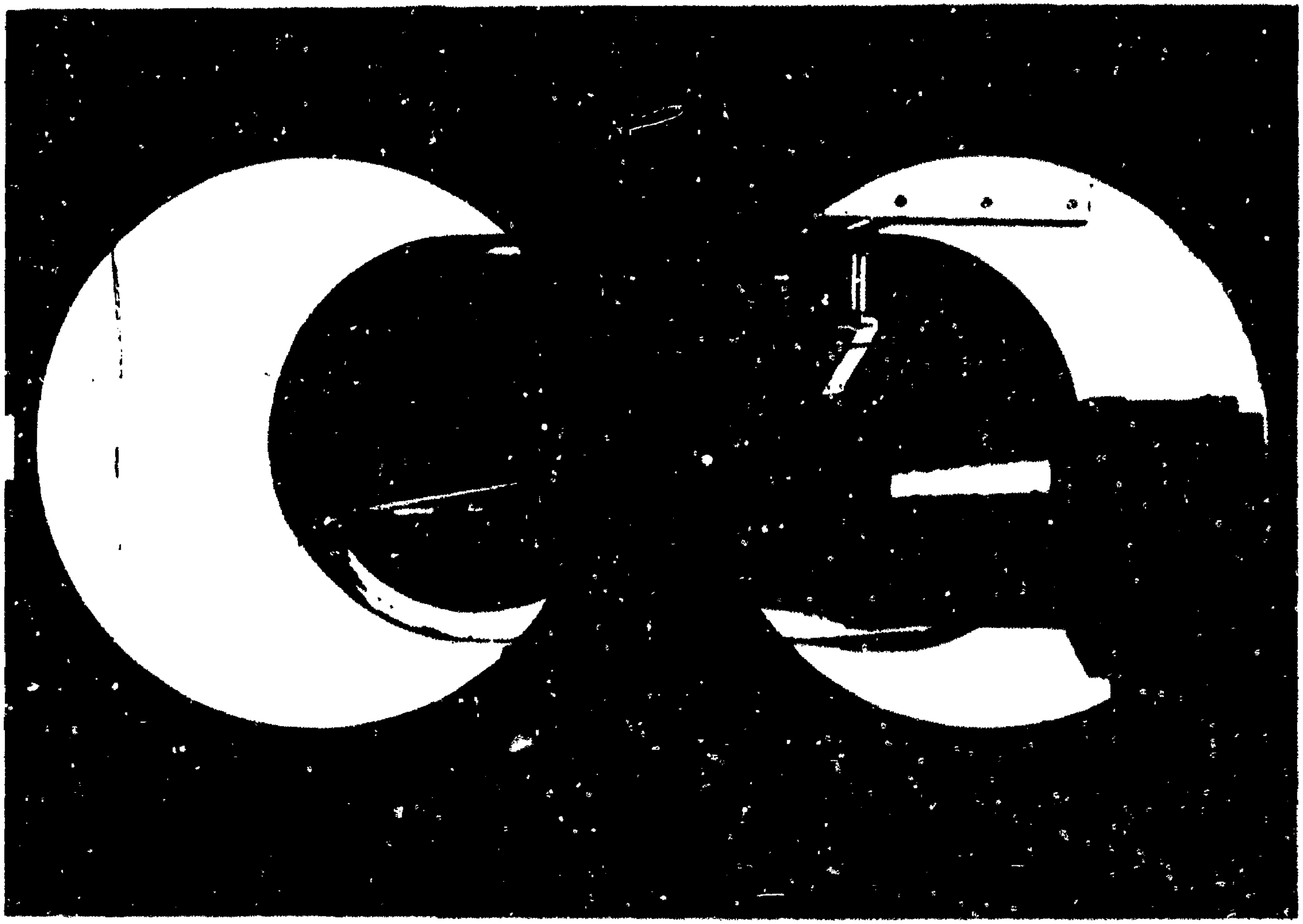


FIGURE 13. PHOTOGRAPH OF THE PROBE ASSEMBLY SHOWN IN PROXIMITY TO THE 10.50/70 BICONE MODEL

Angularity probe was mounted separately. The upper Pitot was moved from 2 inches to 3 inches above the Pitot, Preston, and total temperature probes, when leeward surveys were performed. The second probe was used to minimize data acquisition time for the thick shock layers.

Probe positioning in the vicinity of the model surface, probe deflections and probe spacing are measured and monitored optically with the VKF closed circuit television (CCTV) system. The model and probes are back lighted using the collimated light beam shadowgraph system. The CCTV system can monitor the system at the rate of 30 frames/second, 1224 lines/ frame, and with a magnification factor of 38. Positioning of the probes at a desired location is achieved using a graticule, marked in increments or marked to indicate stations along the model surface. Spacing between the probes and the model surface can also be measured optically. The television image is also used to verify contact between the survey probe and the model surface. The camera is isolated from the tunnel vibrations by mounting it with the optics system which has a separate foundation from the tunnels. A front lighted high magnification TV of approximately 7 power was used to view the 10 degree flap section of the split flap.

2.3.1 Pitot and Unshielded Thermocouple Probes

Total pressure (Pitot) and total temperature probe measurements were used in conjunction with the wall surface static pressure measurements to extract the total pressure and total temperature profiles, and the local Mach number in the boundary layer. To survey boundary layers, probes of small dimensions were used to minimize probe size effects on the resolution of the profiles. Boundary layer probes were designed to obtain measurements close to the surface within the boundary layers and yet remain parallel to the model surface.

The unshielded thermocouple probes were made with Chromel-Alumel thermocouples which had an estimated uncertainty of $\pm$ 1.5^{o}F + 0.375 percent of reading . The unshielded thermocouple probe had a wire junction diameter of approximately 0.007 inches. A reference dimension of 0.005 inches was used for data reduction purposes. The time response and the resolution of the probe location are improved by using such small probes. Total temperature probe uncertainties associated with the heat transfer between the probe and environment were accounted for in the freestream probe calibration (convection and conduction effects).

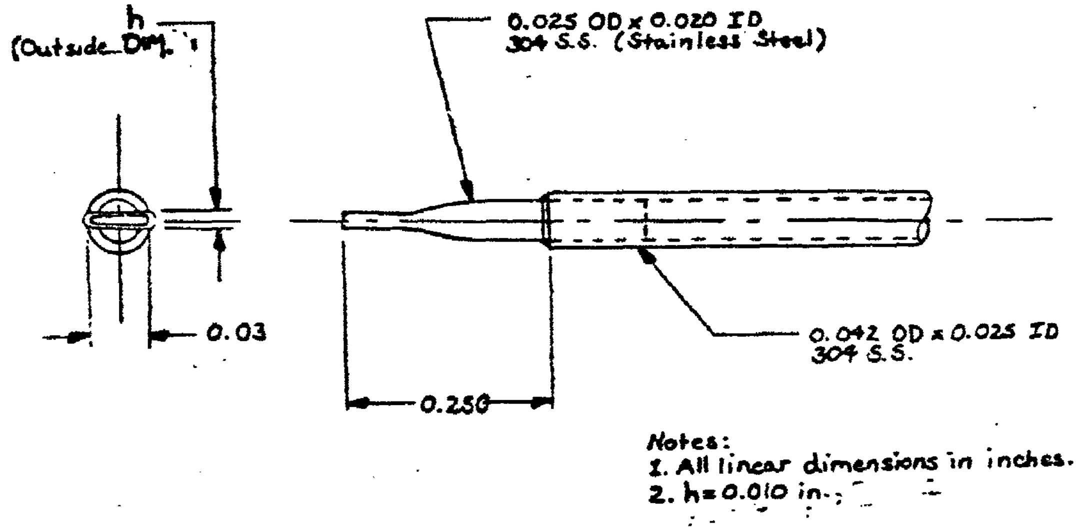
As shown in Figures 10 through 12, two Pitot tubes were attached to the probe holder assembly. Both Pitot probe pressures (on-board and overhead) and the overhead Preston tube were measured with 15-psid Druck^{R} transducers which had an estimated measurement uncertainty of $\pm$ 0.009 psi. A near vacuum reference pressure was used with these transducers. The near vacuum reference pressure was measured with a Hastings absolute pressure transducer. The Pitot probe used for surveys near the model surface were fabricated by flattening an 0.024 inch O.D. (0.020 I.D.) tube as shown in Figure 14. This procedure produced a probe tip thickness of 0.020 inch with an open slit of 0.005 inch height. Pitot and total temperature probes are illustrated in Figure 14.

2.3.2 Preston Tube

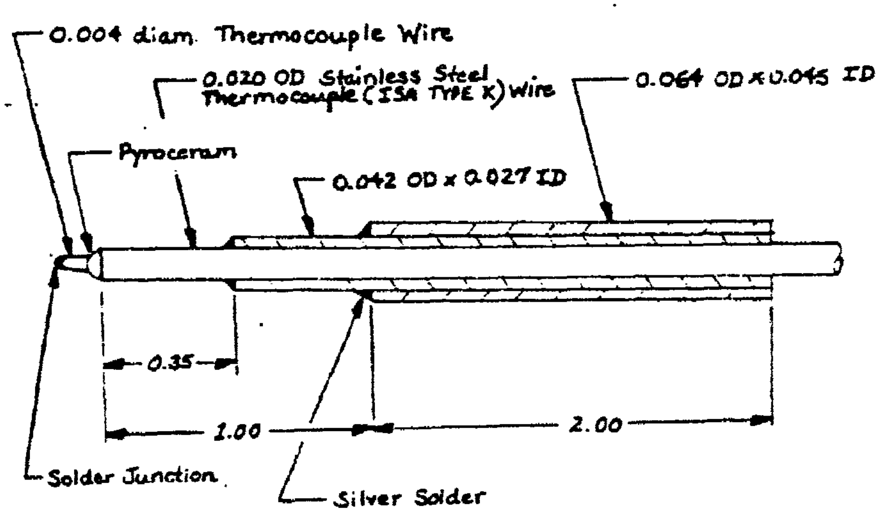
The Preston tube geometry is illustrated in Figure 15. The tube tip dimensions are consistent with those that have been used previously (References 10 and 11) for obtaining Preston tube calibration factors.

2.3.3 Mach/Flow-Angularity Probe

A Mach/flow angularity probe (Probe #5) was used to measure the local stream total pressure, local Mach number, and local flow angle. The Mach/flow angularity probe is shown in Figure 16. The probe is 0.068 inches in diameter, made up of 5 individual tubes of 0.012 inches I.D. Probes this



a. Pitot Probe



b. Unshielded Total Temperature Probe

FIGURE 14. PITOT AND TOTAL TEMPERATURE PROBES

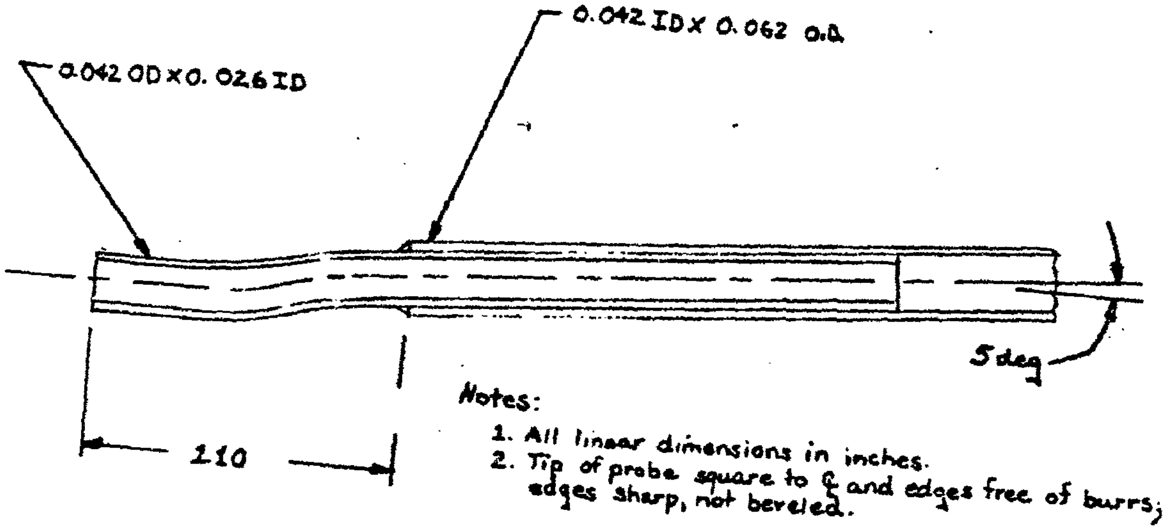


FIGURE 15. PRESTON TUBE

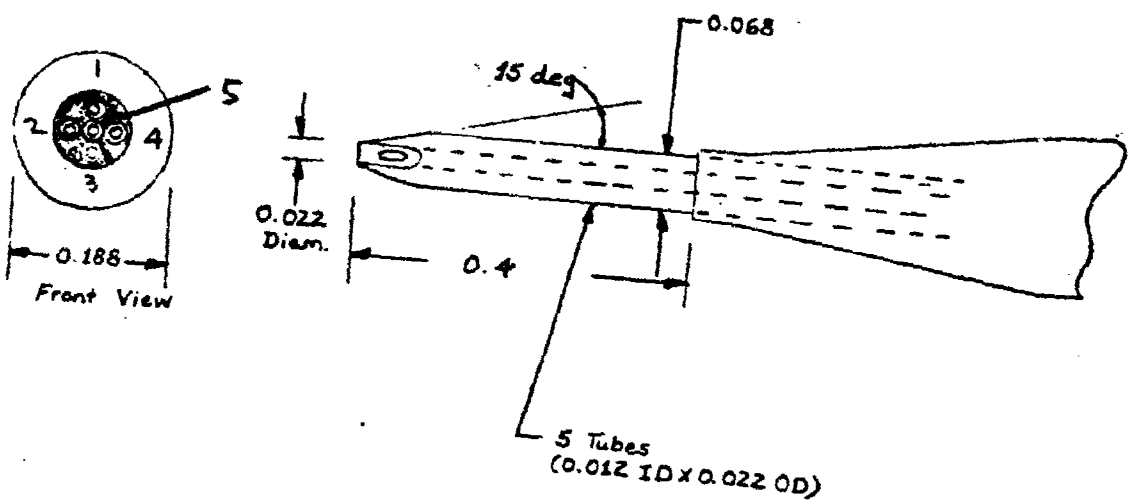


FIGURE 16. MACH/FLOW-ANGULARITY PROBE

small minimize probe interference and improve the resolution of the measurement location while mapping complex flow fields. Mach/flow angularity probes are calibrated to measure the two flow directional angles of the airstream with respect to the probe. Typically, pressure measurements in tubes 1 and 3 are in the vertical or pitch plane and tubes 2 and 4, are in the horizontal or yaw plane of the flow field.

3.0 SUMMARY OF TEST CONDITIONS AND DATA ACQUIRED

A rather large body of detailed experimental data were obtained at AEDC at Mach numbers 6, 8, and 10 on sharp and blunted $10.5^o/7^o$ and $14^o/7^o$ bicones and on a 7^o cone. The data consisted of static force and moment, surface pressure - heat transfer - and shear (via a Preston tube) measurements, and lastly boundary/shock layer surveys. The survey data are composed primarily of Pitot pressure and total temperature with some limited Mach/Flow angularity measurements.

In addition to obtaining data on the axisymmetric configurations, modifications to the aft cone consisting of a windward double slice, a leeward single slice, and the addition of a flap at the second windward slice were made and a full complement of data taken. These data were taken over a 3-4 year span, where the detailed measurements on the $10.5^o/7^o$ bicone with the slices and flap were performed last and were planned and conducted by SAI under the BMO/MAT program sponsorship.

Data were obtained for both laminar and turbulent boundary layer flows. In order to promote turbulence near the nose for the blunted configurations, boundary layer trips were employed. A considerable effort was directed toward defining the minimum trip size that would promote turbulent flow and yet not materially affect the inviscid shock layer flow. This trip investigation was not only performed at zero angle of attack, but also at the larger angles that manuevering vehicles fly (i.e., to 20^o).

Contained in this section of the report is a summary listing of all of the data obtained on these configurations. Specifically, Table 2 presents an overall summary of the data obtained on the 7^o cone, while Table 3 provides a summary of the bicone model data. Sections 3.2 through 3.4 contain details of each of the subset experiments conducted, including detailed AEDC data group numbers for each measurement set.

TABLE 2. SUMMARY OF DATA OBTAINED ON THE SHARP AND BLUNT 7° CONES

CONFIGURATION					FREESTREAM CONDITIONS		DATA ACQUIRED (BY TYPE AND ANGLE OF ATTACK)							TEST DATA SUMMARY
θc (deg)	R_N (in)	TRIP	SLICES (deg)	FLAP (deg)	M_∞	$R_{e_\infty} x10^{-6}/ft$	FORCE & MOMENT	PRESSURE	HEAT TRANSFER	SHOCK LAYER SURVEY α	SHOCK LAYER SURVEY LOCATION	MACH/FLOW ANGLE α	MACH/FLOW ANGLE LOCATION	TABLE NO.
7	SHARP	NO	NONE	NONE	6	1.0	--	--	0^0	--	--	--	--	5
		YES/NO				2.5	--	--	0^0	0^0	FRUSTUM	--	--	
		YES/NO				4.7	--	0^0	0^0	0^0	FRUSTUM	--	--	
		NO			8	0.6	--	--	$0^0,7^0,10^0$	--	--	--	--	8
		NO				1.0	--	--	0^0	0^0	FRUSTUM	--	--	
		NO				2.5	--	--	$0^0,2^0,4^0,7^0,10^0$	--	--	--	--	
		YES/NO				3.7	--	$0^0,4^0$	$0^0,4^0,7^0$	$0^0,4^0$	FRUSTUM	$0^0,4^0$	FRUSTUM	
		NO			10	1.0	$-14^0 \rightarrow 14^0$	--	--	--	--	--	--	10
7	0.1	YES/NO	NONE	NONE	6	4.7	--	--	$0^0,-1^0 \rightarrow 10^0$	--	--	--	--	5
7	0.5	YES/NO	NONE	NONE	6	1.0	--	--	0^0	--	--	--	--	
		YES/NO			6	4.7	--	0^0	$0^0,-1^0 \rightarrow 10^0$	0^0	FRUSTUM	--	--	
		YES/NO			8	1.0	--	--	0^0	0^0	FRUSTUM	--	--	8
		YES				1.5	--	--	$0^0, 7^0$	--	--	--	--	
		YES				2.5	--	--	$0^0, 7^0$	--	--	--	--	
		YES				3.7	$-4^0 \rightarrow 20^0$	$0^0,4^0,10^0$	$0^0,4^0,7^0,10^0$	$0^0,4^0,10^0$	FRUSTUM	$4^0,10^0$	FRUSTUM	8, 13
		NO			10	1.0	$-14^0 \rightarrow 14^0$	--	--	--	--	--	--	10

TABLE 3. SUMMARY OF DATA OBTAINED ON THE SHARP AND BLUNT 10.5°/7° AND 14°/7° BICONES

CONFIGURATION					FREESTREAM CONDITIONS		DATA ACQUIRED (BY TYPE AND ANGLE OF ATTACK)							TEST DATA SUMMARY
θ_c (deg)	R_N (in)	TRIP	SLICES (deg)	FLAP (deg)	M_∞	$Re_\infty \times 10^{-6}$/ft	FORCE & MOMENT	PRESSURE	HEAT TRANSFER	SHOCK LAYER SURVEY α	SHOCK LAYER SURVEY LOCATION	MACH/FLOW ANGLE α	MACH/FLOW ANGLE LOCATION	TABLE NO.
10.5/7	SHARP	YES	NONE	NONE	6	2.5	--	0°	0°	0°	FORECONE FRUSTUM (w/o Preston Tube)	--	--	5
↓	↓	YES/NO	↓	↓		4.7	--	0°	0°	--	--	--	--	5
10.5/7	SHARP	NO	0°/-7°	NONE	8	3.7	-4°→20°	0°, 20°	0°, 20°	0°	FRUSTUM SLICE	--	--	8
↓	↓	↓	↓	10°		↓	-4°→20°	--	0°→10°,20°	--	--	--	--	↓
				20°			-4°→20°	0°	--	0°	FLAP	--	--	
10.5/7	0.50	YES	NONE	NONE	6	2.5	--	--	0°	0°	FRUSTUM	--	--	5
↓	↓	↓	↓	↓		4.7	--	0°	0°	0°	FORECONE FRUSTUM	--	--	5
					8	3.7	-4°→20°	0°,4°,10°	0°,4°,7°, 10°	0°, 4°, 10°	FORECONE FRUSTUM	--	--	8
10.5/7	0.50	YES	0°/-7°	NONE	8	3.7	-4°→20° β=0°,±2°	0°,10°,20°	0°→10°,20°	0°, 10°, 20°	FRUSTUM SLICES	0°,10°, 20°	SLICE	13
↓	↓	↓	↓	10°		↓	-4°→20°	0°,4°,10°	0°→10°,20°	0°, 10°	FLAP	0°,10°	FLAP	↓
				20°			-4°→20°	0°	0°,4°,10° 20°	0°	FLAP	0°	FLAP	
				20°/10°			-4°→20°	0°	--	0°	FLAP	--	--	

TABLE 3. SUMMARY OF DATA OBTAINED ON THE SHARP AND BLUNT 10.5°/7° AND 14°/7° BICONES (CONT'D)

CONFIGURATION					FREESTREAM CONDITIONS		DATA ACQUIRED (BY TYPE AND ANGLE OF ATTACK)							TEST DATA SUMMARY
θ_c (deg)	R_N (in)	TRIP	SLICES (deg)	FLAP (deg)	M_∞	$Re_\infty \times 10^{-6}$/ft	FORCE & MOMENT	PRESSURE	HEAT TRANSFER	SHOCK LAYER SURVEY α	SHOCK LAYER SURVEY LOCATION	MACH/FLOW ANGLE α	MACH/FLOW ANGLE LOCATION	TABLE NO.
14/7	SHARP	YES	NONE	NONE	6	2.5	--	--	0^0	0^0	FRUSTUM	--	--	5
↓	↓	YES/NO	↓	↓	6	4.7	--	--	0^0	--	--	--	--	↓
14/7	0.5	YES/NO	NONE	NONE	6	2.5	--	0^0	0^0	0^0	FRUSTUM	--	--	5
		YES/NO			6	4.7	--	0^0	$0^0, -1^0 \rightarrow 14^0$	0^0	FRUSTUM	--	--	↓
		YES			8	3.7	--	--	$0^0, 4^0, 7^0, 10^0$	--	--	--	--	8
↓	↓	NO	↓	↓	10	1.0	$-14^0 \rightarrow 14^0$	--	--	--	--	--	--	10
14/7	0.5	NO	$0^0/0^0$	NONE	10	1.0	$-14^0 \rightarrow 14^0$	--	--	--	--	--	--	10
14/7	0.5	NO	$0^0/-7^0$	NONE	10	0.55	--	--	$0^0, 2^0, 5^0, 10^0, 14^0$	--	--	--	--	10
↓	↓	↓	↓	↓	10	1.0	$-14^0 \rightarrow 14^0$	$2^0, 10^0$	0^0 14^0	$2^0, 10^0$	FRUSTUM SLICES	$2^0, 10^0$	FRUSTUM SLICES	10

3.1 Axisymmetric Body - Turbulent Flow; $M_\infty = 6, \alpha = 0$ (References 4 and 5)

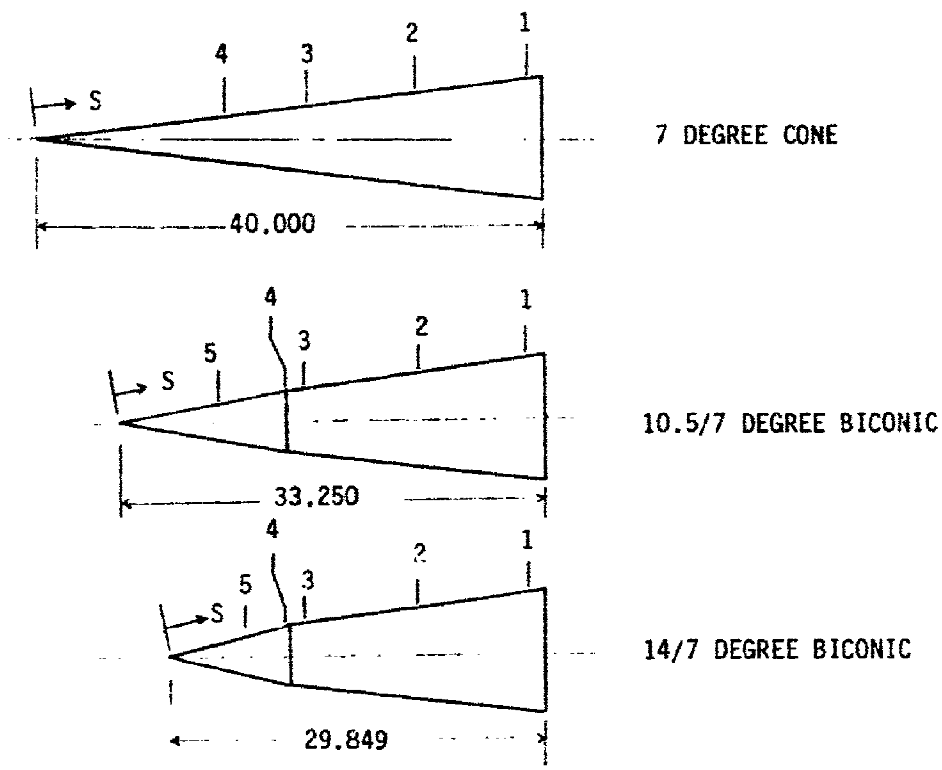
The testing of the axisymmetric 7^0 cone, and $10.5^0/7^0$ and $14^0/7^0$ bicones were conducted in two phases. The objective of the first phase was to determine the smallest boundary layer trip that would bring boundary layer transition near the trip without introducing disturbances in the flow field. A boundary layer trip that brought the end of the transition in the vicinity of the first heat gage (s = 8.15 for the 7^0 cone, and 3.91 for the $14^0/7^0$ bicone) was considered effective and suitable to be studied in more detail. This initial approach was taken since the ultimate goal was to fix the end of transition on the forebody of the biconic configurations to be studied in detail in later test phases.

The objective of the second test phase was to evaluate the influence of boundary layer trips on boundary layer and flow field characteristics. Flow field surveys were performed at several longitudinal body stations on configurations with different nosetips and trip combinations. Corresponding heat transfer data were obtained to identify transition and verify that turbulent flow existed at the probe survey stations.

Figure 17 lists the survey station for each basic body configuration while Table 4 indicates the location of the surface instrumentation for each of the three configurations.

A summary of the nominal test conditions at each Reynolds number is given below:

M_∞	p_0,psia	T_0,^{0}R	$\rho_\infty x10^5$ slugs/ft^3	q_∞,psia	p_∞,psia	$Re_\infty/ft \times 10^{-6}$
5.91	55	845	2.98	0.919	0.037	1.0
5.94	131	845	7.06	2.180	0.088	2.5
5.95	250	845	13.37	4.131	0.167	4.7

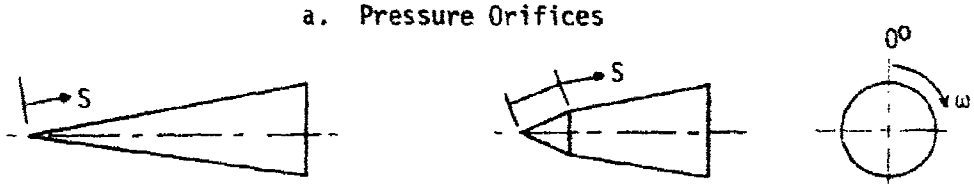


	S, IN.		
STATION NO.	7 DEGREE CONE	10.5/7 DEGREE BICONIC	14/7 DEGREE BICONIC
1	38.800	32.125	28.801
2	30.300	23.625	20.301
3	20.150	14.486	11.162
4	15.150	13.233	9.909
5	-	8.483	6.159

Figure 17. Probe Survey Locations

Table 4. Surface Instrumentation Locations

a. Pressure Orifices



	S, IN.			
ORIFICE NO.	7 DEGREE CONE	10.5/7 DEGREE BICONIC	14/7 DEGREE BICONIC	ω DEG.
1	39.800	33.125	29.801	0
2	38.300	31.625	28.301	
3	36.300	29.625	26.301	
4	34.300	27.625	24.301	
5	32.300	25.625	22.301	
6	30.300	23.625	20.301	
7	28.300	21.625	18.301	
8	26.300	19.625	16.301	
9	24.300	17.625	14.301	
10	22.300	15.625	12.301	
11	20.150	14.486	11.162	
12	17.150	14.111	10.787	
13	15.150	13.736	10.412	
14	13.150	13.233	9.909	
15	11.150	12.483	9.159	
16	9.150	10.483	7.159	
17	8.150	8.483	6.159	
18	-	7.483	5.159	
19	-	6.483	4.659	
20	-	5.483	4.159	
21	-	4.983	3.659	
22	39.800	33.125	29.801	-90
23	30.300	23.625	20.301	
24	11.150	5.483	4.659	
25	39.800	33.125	29.801	90
26	30.300	23.625	20.301	
27	11.150	5.483	4.659	
28	39.800	33.125	29.801	180
29	30.300	23.625	20.301	
30	11.150	5.483	4.659	
31	BASE	BASE	BASE	0
32	BASE	BASE	BASE	180
33	38.800	32.125	28.801	0

TABLE 4. SURFACE INSTRUMENTATION LOCATIONS (CONT'D)

b. Heat Gages

GAGE NO.	S, IN. 7 DEGREE CONE	S, IN. 10.5/7 DEGREE BICONIC	S, IN. 14/7 DEGREE BICONIC	ω DEG.
1	38.300	31.625	28.301	180
2	36.300	29.625	26.301	
3	34.300	27.625	24.301	
4	32.340	25.565	22.241	
5	28.240	21.565	18.241	
6	26.240	19.565	16.241	
7	25.240	18.565	15.241	
8	24.240	17.565	14.241	
9	23.240	16.565	13.241	
10	22.240	15.565	12.241	
11	21.150	14.486	11.162	
12	20.150	14.111	10.787	
13	19.150	13.736	10.412	
14	18.150	13.233	9.909	
15	17.150	12.233	9.159	
16	15.150	10.483	7.159	
17	13.150	7.483	6.159	
18	9.150	6.233	5.159	
19	8.150	4.983	3.909	

Transition location was determined from the heat transfer distribution obtained with the Gardon heat-flux gages. Prior to each run the model was cooled to approximately 520°R by flowing air over the model. The model was injected into the tunnel flow for about five seconds while a continuous record of gage output was recorded. Data presented in the Data Package were reduced approximately one second after the model reached the centerline of the wind tunnel. Some runs were obtained with a hot wall to minimize the time required for a full cooling cycle. Since the thermal driving potential (T_o - T_w) was low for these cases, the data uncertainty was significantly greater than the cool wall data. However, these data were qualitatively useful in determining the presence of transition.

Surface pressure distributions were obtained on selected configurations. It should be noted that surface pressure at each probe station was obtained each time a survey point was recorded. This procedure made it possible to confirm that local wall pressure had been obtained in the absence of any local probe disturbance or interference.

Initial probe positioning on the model wall was monitored with the closed circuit television system (CCTV). The television image was used to monitor probe longitudinal location and to verify Preston tube and Pitot probe contact with the model surface. At each survey station, a reference mark was painted on the model surface with black paint to provide an optical target for positioning the probe. The Preston tube and Pitot tube were brought down until they both were in contact with the model surface. It is estimated that the probe was located axially to within ± 0.050 inches of the reference marks.

Initial data were obtained with the Preston tube and Pitot tube in contact with the model surface. The first three probe positions above the model surface were obtained using manual probe drive control to achieve the desired small height increments between points. Remaining points in the survey were obtained using an automatic system which drove the probe to predetermined locations above the model surface. Note that the only point valid for the Preston tube measurements was the initial point at the model wall. Each survey consisted of approximately 50 points.

Table 5a through 5c present the AEDC data group numbers from References 4 and 5 (and the complementary data tabulations) for each configuration tested for the heat transfer, pressure, and shock layer survey tests, respectively.

3.2 Axisymmetric Body-Turbulent Flow: Mach 8, $\alpha=0$ (Reference 6)

The overall test objective was to obtain a turbulent-flow data base with which to validate and develop analytical codes to be used in predicting the hypersonic aerodynamic characteristics of conic and biconic bodies at angles of attack. Data obtained in this series includes surface heat transfer, pressure, and detailed flow field measurements including flow-angle information.

A major portion of the test was devoted to flow-field surveys over two basic configurations, the 7-degree cone (sharp and blunt nose) and the blunt biconic configuration (fore cone/aft cone angles of 10.5 deg/7 deg) at Mach number 8. Windward and leeward surveys were obtained at several model stations, from the model surface to the bow shock using a probing mechanism located on top of the tunnel. In addition, radial surveys were obtained at one model station near the base by using an "onboard" probing mechanism. Roll positions relative to the windward plane of symmetry for these radial surveys were: 50, 75, 100, 120, 140, and 160 degrees. Flow-field probes on the survey mechanisms were: Pitot probes, unshielded thermocouple probes, a Preston tube and a Mach/Flow-Angularity probe.

Surface pressures were measured to provide pressure data for boundary layer calculations, and heat-transfer distributions were obtained to determine the boundary layer state. A machined boundary layer trip was used for the majority of the tests, to provide the desired fully developed turbulent boundary layer. Surface shear stress data were obtained using a flow-angle sensitive Preston tube attached to the model. Data were

Table 5A. Heat Transfer Data Summary - Mach 6, $\alpha = 0$

Configuration θ	Configuration R_N (IN.)	Configuration Trip Ht. (IN.)	$Re_\infty \times 10^{-6}$ ft^{-1}	Meridian Angle, ω 0^0	Meridian Angle, ω 90^0	Meridian Angle, ω 180^0	Remarks
7^0	0	NONE	4.7	1, 2, 37 93, 97, 109, 110	14	15, 94	
	0.05	NONE	1.0	56	--	--	
		NONE	2.5	52	--	--	
		NONE	4.7	22	--	30	
		.010	4.7	8, 10, 23+, 29, 38	9	30, 39	+ Grooves
		.022	2.5	51	--	--	
		.037	1.0	59	--	--	
	0.10	NONE	4.7	24	--	--	
	0.10	.014	4.7	16	--	--	
	0.50	NONE	1.0	57	--	--	
		NONE	2.5	48	--	--	
		NONE	4.7	3, 4, 112	5	--	
		.0065	4.7	11	12	13	
		.010	4.7	17, 18, 19 20, 21, 27, 43	--	28	18: α SWEEP, $-1^0 \rightarrow 10^0$ 19: $0 \rightarrow 180^0$ ROLL @ $\alpha=0^0$ 20: $0 \rightarrow 180^0$ ROLL @ $\alpha=5^0$ 21: $0 \rightarrow 180^0$ ROLL @ $\alpha=10^0$
		.014	4.7	7, 113, 124	--	--	
		.022	2.5	47	--	--	
		.037	1.0	58	--	--	
		.093	4.7	114	--	--	

TABLE 5A. HEAT TRANSFER DATA SUMMARY - MACH 6, $\alpha = 0$ (CONT'D)

CONFIGURATION			$Re_\alpha \times 10^{-6}$ ft^{-1}	MERIDIAN ANGLE, ω			REMARKS
	R_N (IN.)	TRIP HT. (IN.)		0°	90°	180°	
$10.5^\circ/7^\circ$	0.05	NONE	4.7	129, 131	--	130	
↓	0.05	.010	2.5	156	--	157	
↓	0.50	.010	4.7	132	--	--	
↓	↓	.046	4.7	153, 154	--	--	
↓	↓	.022	2.5	171	--	172	HOT WALL H.T.
↓	↓	.125	2.5	173, 174	--	--	HOT WALL H.T.
$14^\circ/7^\circ$	0.05	NONE	4.7	66	--	67	
↓	↓	GROOVES	4.7	68	--	69	
↓	↓	.010	2.5	205	--	--	HOT WALL H.T.
↓	↓	.046	2.5	206	--	--	HOT WALL H.T.
↓	0.50	NONE	2.5	70, 177	--	--	
↓	↓	.0048	4.7	72	--	--	
↓	↓	.0065	4.7	64, 73, 74*, 77, 78*, 80, 86	91^+ 76^+ 79^{++}	65, 75* 81*	+ ROLL $0 \rightarrow 180^\circ$ * $\alpha \rightarrow -1$ to $+14^\circ$ ++ $\alpha = 14^\circ$ ROLL $0 \rightarrow 180^\circ$
↓	↓	.014	2.5	178, 202, 203, 204	--	179	
↓	↓	.093	2.5	180, 181	--	--	

TABLE 5B. SURFACE PRESSURE DATA SUMMARY - MACH 6, α = 0

CONFIGURATION			$Re_\infty \times 10^{-6}$ ft^{-1}	MERIDIAN ANGLE, ω		
θ	R_N (IN.)	TRIP HT. (IN.)		0^o	90^o	180^o
7^o	0	NONE	4.7	31, 33, 61, 100	--	32, 99
↓	0.50	.010		41, 62	--	--
		.014		125	--	126
		.093		116	--	--
$10.5^o/7^o$	0.05	.010	4.7	134, 159	--	135, 160
↓	0.50	.010	4.7	137	--	--
$14^o/7^o$	0.50	.0065	4.7	82, 83	--	--
↓		.093	2.5	183, 185	--	--
		.014	2.5	198	--	--

TABLE 5C. PROFILE DATA SUMMARY - MACH 6, $\alpha = 0$

CONFIGURATION			$Re_\infty \times 10^{-6}$ ft^{-1}	PROBE SYSTEM	
θ	R_N (IN.)	TRIP HT. (IN.)		ON-BOARD	OVERHEAD*
7°	0	NONE	4.7	34, 102, 103	36, 106, 107, 215, 217
↓	.05	.011	2.5	--	219, 220
	.50	NONE	4.7	26	--
	.50	NONE	1.0	60	--
	.50	.010-.014	4.7	25, 42, 123	119, 120, 218
	.50	.093	4.7	118	117
10.5°/7°	.05	.010	2.5	--	161, 162, 163
↓	.50	.010	4.7	--	139, 143, 146, 148, 149
	.50	.022	2.5	--	168, 169
	.50	.046	4.7	--	150, 151
	.50	.125	2.5	--	164, 165, 166, 167
14°/7°	.05	.010	2.5	--	213, 214
↓	.05	.046	2.5	--	207, 208
	.05	.093	2.5	--	209, 210, 211
	.50	.0065	4.7	84	85
	.50	.014	2.5	--	199, 200, 201
	.50	.093	2.5	--	188, 190, 192, 193, 195

* DATA TAKEN AT SEVERAL AXIAL STATIONS

obtained at free-stream Reynolds numbers from 0.5 to 3.7 million per ft, with the majority of the results obtained at 3.7 million per ft. Model angles of attack were from -10 to 10 deg and model roll angles were from 0 to 180 deg.

The locations of the heat transfer gages for the sharp 7^o and blunt 7^o cones, and the blunt $10.5^o/7^o$ and $14^o/7^o$ bicones are listed in Tables 6a to 6d, respectively. Similarly, the locations of the surface pressure orifices, including the identification of the profile measuring stations for the sharp and blunt 7^o cone and the blunt $10.5^o/7^o$ bicone are listed in Tables 7a to 7c, respectively.

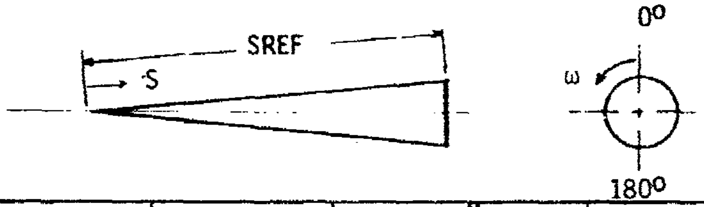
A summary of the nominal test conditions at each Mach number is given below.

M_∞	p_0, psia	T_0, ^oR	q_∞, psia	p_∞, psia	$Re_\infty \times 10^{-6}$/ft
7.90	100	1220	0.485	0.011	0.5
7.91	125	1285	0.603	0.014	0.6
7.94	210	1280	0.997	0.023	1.0
7.97	330	1310	1.540	0.035	1.5
7.99	560	1330	2.584	0.058	2.5
8.00	850	1350	3.900	0.087	3.7

Heat-transfer distribution data were obtained with high-sensitivity thermopile heat-flux gages (Gardon type). These data were taken to determine transition locations, and to evaluate trip effectiveness. In most cases the model was injected into the tunnel flow at a fixed model attitude. The data were recorded continuously for a period of about 5 seconds beginning one second after the model reached tunnel centerline. The model was then retracted into the test section tank and cooled with high pressure air. Model wall temperature typically did not exceed 600^oR during data acquisition. One series of runs was made using the continuous roll sweep mode; with the model pitched at four degrees the model was rolled from 0 to 180 degrees while recording the data continuously.

Table 6. Heat Transfer Gage Locations

a. 7 Degree Sharp Cone (RN = 0.0015 in.)

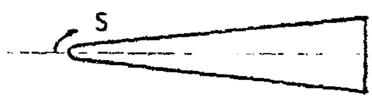


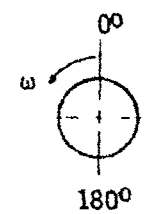
Gage No.	S, In.	S/SREF	ω, DEG.	Gage No.	S, IN.	S/SREF	ω, DEG.
1	38.790	0.963	180	18	22.230	0.552	180
2	38.290	0.950		19	21.140	0.525	
3	37.590	0.933		20	20.140	0.500	
4	36.290	0.901		21	19.140	0.475	
5	35.290	0.876		22	18.140	0.450	
6	34.290	0.851		23	17.140	0.425	
7	33.290	0.826		24	16.140	0.401	
8	32.230	0.800		25	15.140	0.376	
9	31.230	0.772		26	14.140	0.351	
10	29.930	0.743		27	13.140	0.326	
11	29.230	0.726		28	12.140	0.301	
12	28.230	0.701		29	10.840	0.269	
13	27.230	0.676		30	10.140	0.252	
14	26.230	0.651		31	9.140	0.227	
15	25.230	0.626		32	8.140	0.202	
16	24.230	0.601		39	38.791	0.963	5
17	23.230	0.577		40	38.791	0.963	15

SREF = 40.291 IN.

TABLE 6. HEAT TRANSFER GAGE LOCATIONS (CONT.D)

b. 7 Degree Blunt Cone (RN = 0.50 in.)



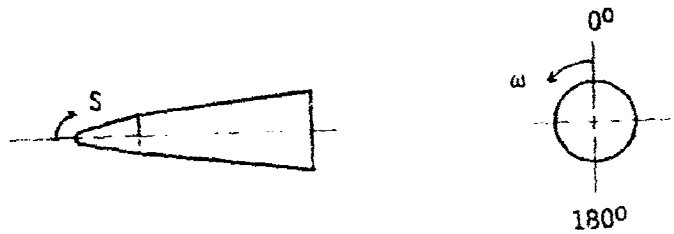


Gage No.	S, In.	S/SREF	ω, DEG.	Gage No.	S, IN.	S/SREF	ω, DEG.
1	35.452	0.959	180	18	18.892	0.511	180
2	34.952	0.946		19	17.802	0.482	
3	34.252	0.927		20	16.802	0.455	
4	32.952	0.892		21	15.802	0.428	
5	31.952	0.865		22	14.802	0.401	
6	30.952	0.837		23	13.802	0.374	
7	29.952	0.811		24	12.802	0.346	
8	28.892	0.782		25	11.802	0.319	
9	27.892	0.755		26	10.802	0.292	
10	26.592	0.720		27	9.802	0.265	
11	25.892	0.701		28	8.802	0.238	
12	24.892	0.674		29	7.502	0.203	
13	23.892	0.647		30	6.802	0.184	
14	22.892	0.620		31	5.802	0.157	
15	21.892	0.592		32	4.802	0.130	
16	20.892	0.565		39	35.453	0.959	
17	19.892	0.538		40	35.453	0.959	

SREF = 36.953 IN.

Table 6. Heat Transfer Gage Locations (Cont'd)

c. 10.5/7 Degree Biconic (RN = 0.50 in)

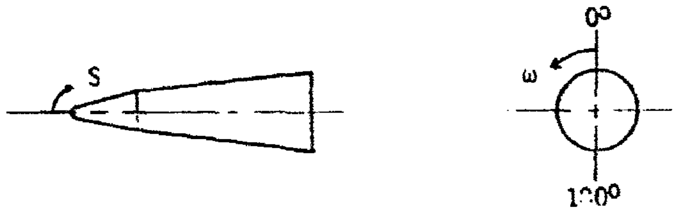


Gage No.	S, In.	S/SREF	ω, DEG.	Gage No.	S, IN.	S/SREF	ω, DEG.
1	30.123	0.953	180	17	14.563	0.461	180
2	29.623	0.937		18	13.563	0.429	
3	28.923	0.915		19	12.484	0.395	
4	27.623	0.874		20	12.109	0.383	
5	26.623	0.842		21	11.734	0.371	
6	25.623	0.810		22	11.231	0.355	
7	24.623	0.779		23	10.231	0.324	
8	23.563	0.745		24	9.354	0.296	
9	22.563	0.714		25	8.481	0.268	
10	21.263	0.672		26	7.479	0.237	
11	20.563	0.650		27	6.479	0.205	
12	19.563	0.619		28	5.481	0.173	
13	18.563	0.587		29	4.231	0.134	
14	17.563	0.555		30	2.981	0.094	
15	16.563	0.524		39	30.123	0.953	5
16	15.563	0.492		40	30.123	0.953	15

SREF = 31.623 IN.

TABLE 6. HEAT TRANSFER GAGE LOCATIONS (CONT'D)

d. 14/7 Degree Biconic (RN = 0.50 in)

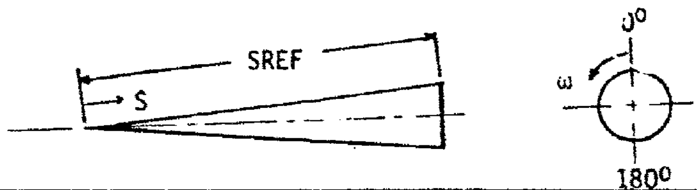


Gage No.	S, In.	S/SREF	ω, DEG.	Gage No.	S, IN.	S/SREF	ω, DEG.
1	27.46	0.948	180	18	10.90	0.376	180
2	26.96	0.931		19	9.82	0.339	
3	26.26	0.907		20	9.45	0.326	
4	24.96	0.862		21	9.07	0.313	
5	23.96	0.827		22	8.56	0.296	
6	22.96	0.793		23	7.81	0.270	
7	21.96	0.758		24	6.81	0.235	
8	20.90	0.722		25	5.81	0.201	
9	19.90	0.687		26	4.81	0.166	
10	18.60	0.642		27	3.81	0.132	
11	17.90	0.618		28	2.56	0.088	↓
12	16.90	0.584		33	28.46	0.983	40
13	15.90	0.549		34			50
14	14.90	0.515		35	↓	↓	60
15	13.90	0.480		36	18.90	0.653	40
16	12.90	0.445		37			50
17	11.90	0.411	↓	38	↓	↓	60

SREF = 28.96 IN.

Table 7. Pressure Orifice Locations

a. 7 Degree Sharp Cone (RN = 0.0015 in.)



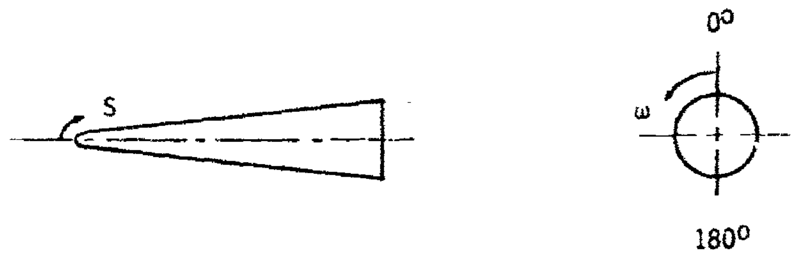
Orifice No.	S, In.	S/SREF	ω, DEG	Orifice No.	S, In.	S/SREF	ω, DEG
1	39.791	0.988	0	15	13.141	0.326	0
2*	38.791	0.963	↓	16	11.141	0.277	↓
3	38.291	0.950		17	9.141	0.227	
4	36.291	0.901		18	8.141	0.202	
5	34.291	0.851		19	11.141	0.277	90
6	32.231	0.800		20	11.141	0.277	180
7	30.231	0.750		21	11.141	0.277	270
8*	28.231	0.701		26	30.231	0.750	90
9	26.231	0.651		27	30.231	0.750	180
10	24.231	0.601		28	30.231	0.750	270
11	22.231	0.552		29	39.791	0.988	90
12	20.141	0.500		30	39.791	0.988	180
13*	17.141	0.425		31	39.791	0.988	270
14	15.141	0.376					

SREF = 40.291 IN.

* Probe Survey Locations

Table 7. Pressure Orifice Locations (Cont'd)

b. 7 Degree Blunt Cone (RN = 0.50 in.)



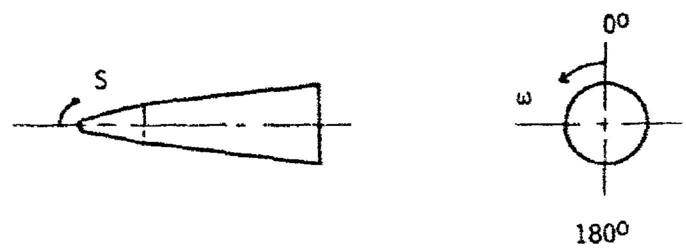
Orifice No.	S, IN.	S/SREF	ω, DEG.	Orifice No.	S, IN.	S/SREF	ω, DEG
1	36.453	0.986	0	14	11.803	0.319	0
2*	35.453	0.959		15	9.803	0.265	
3	34.953	0.946		16	7.803	0.211	
4	32.953	0.892		17	5.803	0.157	
5	30.953	0.838		18	4.803	0.130	
6	28.893	0.782		19	7.803	0.211	90
7	26.893	0.728		20	7.803	0.211	180
8*	24.893	0.674		21	7.803	0.211	270
9	22.893	0.620		26	26.893	0.728	90
10	20.893	0.565		27	26.893	0.728	180
11	18.893	0.511		28	26.893	0.728	270
12	16.803	0.455		29	36.453	0.986	90
13*	13.803	0.374		30	36.453	0.986	180
				31	36.453	0.986	270

SREF = 36.953 IN.

* Probe Survey Locations

TABLE 7. PRESSURE ORIFICE LOCATIONS (CONT'D)

c. 10.5/7 Degree Biconic (RN = 0.50 in.)



Orifice No.	S, IN.	S/SREF	ω, DEG.	Orifice No.	S, IN.	S/SREF	ω, DEG
1	31.123	0.984	0	17	8.841	0.268	0
2*	30.123	0.953		18*	6.481	0.205	
3	29.623	0.937		19	5.481	0.173	
4	27.623	0.874		20	4.481	0.142	
5	25.623	0.810		21	3.481	0.110	
6*	23.563	0.745		22	2.981	0.094	
7	21.563	0.682		23	3.481	0.110	90
8	19.563	0.619		24	3.481	0.110	180
9*	17.563	0.555		25	3.481	0.110	270
10	15.563	0.492		26	21.563	0.682	90
11	13.563	0.429		27	21.563	0.682	180
12	12.484	0.395		28	21.563	0.632	270
13	12.109	0.383		29	31.123	0.984	90
14	11.734	0.371		30	31.123	0.984	180
15	11.231	0.355		31	31.123	0.984	270
16*	10.481	0.331					

SREF = 31.623 IN.

* Probe Survey Locations

Data acquisition procedures can be divided into various data types: (1) heat-transfer data, (2) surface pressure and flow-angle sensitive Preston tube data, (3) overhead probe surveys, (4) onboard probe surveys, (5) Mach/Flow-Angularity probe calibrations and (6) total temperature probe calibrations. The data acquisition procedures for each type are discussed in the subsequent paragraphs.

Heat-transfer distribution data were obtained with coaxial surface thermocouple gages. The model attitude was preset, and the model was then injected into the tunnel flow while recording data continuously. During this time the model wall temperatures were nominally 540 to 580^{O}R. The model was in the tunnel flow (injection to retraction) approximately 6 sec. Model cooling was accomplished in the test section tank between injections by blowing high pressure air over the model.

Surface pressure data, and flow-angle sensitive Preston tube data were obtained at 3 angles of attack and 8 model roll angles. In each case, data acquisition was essentially the same, since the pressures were measured using the AEDC "standard pressure system."

Flow-field surveys with the overhead probes were taken from the model surface to just beyond the bow shock. A survey run typically consisted of 40 to 100 data points obtained at different heights above the model surface. The probe direction of travel (Z' drive direction) was nominally along a "surface normal". The small size of the probe presented a major problem in obtaining high quality pressure measurements, namely, the small tube size causes severe pressure lag or stabilization problems. To alleviate this problem, time-wise data were recorded to provide pressure-time histories which were used to evaluate or define the equilibrium pressures.

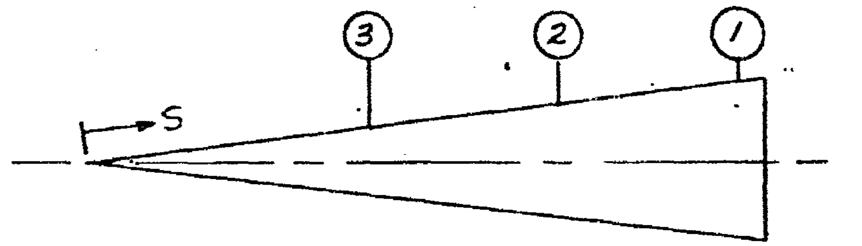
The following data taking sequence was used: (1) the probe was moved to predetermined height and (2) the data acquisition system waited a prescribed delay time (2 to 5 seconds) and then recorded 40 loops of data at a constant time interval (0.1 seconds) which provided pressure-time histories. Positioning the probe on the model surface was monitored optically. An automatic control sytem was used to drive the probe except at points near the model surface ($ZP \leq 0.09$ in.). Overhead probe survey locations are shown in Figure 18.

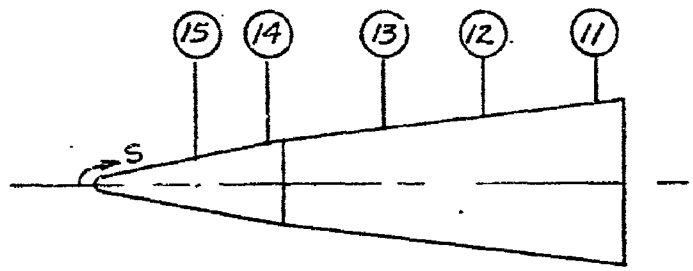
Flow-field surveys with the onboard probes were almost identical in data acquisition technique to the overhead surveys. However the onboard probes typically did not get outside the bow shock due to the mechanism limit of travel (2.5 in. maximum). The probes were positioned on the model surface, and then the model was rolled to the desired attitude before starting a survey. Thus most surveys with the onboard probes were conducted without optical monitoring.

Mach/Flow-Angularity probe calibrations were obtained in the freestream at discrete probe pitch attitudesm from 3 to 25 degrees. The calibration data were obtained at several freestream Reynolds number conditions in order to evaluate Reynolds number effects.

Total temperature probe calibrations were obtained in the freestream for each probe used. For these calibration runs, the total pressure (P_0) was varied in 50 psi increments from 150 to 850 psia. Total temperature probe data and tunnel conditions were recorded at each pressure level and used to determine Reynolds number effects on the unshielded total temperature probes.

Tables 8a through 8e present the AEDC data group numbers from Reference 6 (along with the complementary data tabulations) for each configuration tested and data type.





7 DEGREE CONE

STA. NO.	** PRES. ORIF.	RN = 0.0015"		RN = 0.5"	
		S, IN.	S/SREF.	S, IN.	S/SREF.
1*	2	38.791	0.963	35.453	0.959
2	8	28.231	0.701	24.893	0.674
3	13	17.141	0.425	13.803	0.374

10.5/7 BICONIC

STA. NO.	** PRES. ORIF.	RN = 0.5"	
		S, IN.	S/SREF.
11*	2	30.123	0.953
12	6	23.563	0.745
13	9	17.563	0.555
14	16	10.481	0.331
15	18	6.481	0.205

*ON-BOARD SURVEY LOCATION ALSO

**PRESSURE ORIFICES ARE AT AXIAL LOCATION OF SURVEY STATION BUT ROLLED 180 DEGREES FROM PROBE DURING SURVEYS

FIGURE 18. OVERHEAD PROBE SURVEY LOCATIONS

TABLE 8. TEST DATA SUMMARY - AXISYMMETRIC MODELS @ MACH 8

a. Gardon Gage Heat Transfer Data

MODEL CONFIGURATION: CONE ANGLE	RN IN.	TRIP HT., IN.	$Re_\infty \times 10^6$, FT^{-1}	α DEG.	MODEL ROLL ANGLE (ω), DEG.: WIND 0	45	90	135	LEE 180
									RUN
7°	0.0	NONE	0.6	0	-	-	-	-	1
				7	-	-	-	-	2
				10	-	-	-	-	3
			1.0	0	-	-	-	-	4
			2.5	0	-	-	-	-	12,20
				2	16	17	18	19	26
				4	(0 - 180 ROLL SWEEP)				15
				7	14,21	22	23	24	13,25
				10	27	28	29	30	31
			3.7	0	32	-	-	-	-
				4	33	34	35	36	37
				7	38	39	40	41	42
	0.5	NONE	1.0	0	-	-	-	-	5
		.033		0	-	-	-	-	6
			1.5	0	-	-	-	-	7
				7	-	-	-	-	8
			2.5	0	-	-	-	-	9
				7	11	-	-	-	10
			3.7	0	43	-	-	-	-
				4	44	45	-	-	46
				7	47	48	49	50	51
				10	52	53	54	55	56
10.5°/7°		.015		0	57	-	-	-	-
				4	58	59	-	-	-
		.033		0	60	-	-	-	-
				4	61	62	63	64	65,76*
				7	66	67	68	69	70,77*
				10	71	72	73	74	75,78*
		.037		0	79,85	-	-	-	-
				7	80	81	82	83	84
14°/7°		.021		0	86	-	-	-	-
				4	87	88	89	90	91
				7	92	93	94	95	96
				10	97	98	99	100	101
		.028		0	102,108	-	-	-	-
				7	103	104	105	106	107

*Model Roll = 157° for Runs 76, 77, 78

Table 8. Test Data Summary - Axisymmetric Models @ Mach 8 (Cont'd)

b. Coax Gage Heat Transfer Data

$M_\infty = 8$

$Re_\infty = 3.7 \times 10^6\ FT^{-1}$

B. L. TRIP = .06 IN.

MODEL CONFIGURATION			MODEL ROLL ANGLE (ω), DEG.							
CONE ANGLE	RN IN.	α DEG.	WIND 0	-50	-75	-100	-120	-140	-160	LEE -180
7°	0.0015	0	8	-	-	-	-	-	-	-
↓	↓	4	204	205	-	206	-	207	-	208
7°	.50	0	318,5	-	-	-	-	-	-	-
		4	39,6	36	319	35	320	34	321	33,7
↓	↓	10	63	62	209,212	61	210	60	211	59
10.5°/7°	.50	0	253	-	-	-	-	-	-	-
		4	254	255	-	256	-	257	-	258
↓	↓	10	261	262	266	263	267	264	268	265

TABLE 8. TEST DATA SUMMARY - AXISYMMETRIC MODELS @ MACH 8 (CONT'D)

c. Model Surface Pressure Data

$M_\infty = 8$

$Re_\infty = 3.7 \times 10^6$ FT^{-1}

B. L. TRIP = .06 IN.

MODEL CONFIGURATION			MODEL ROLL ANGLE (ω), DEG.							
CONE ANGLE	RN IN.	α DEG.	WIND -180	-130	-105	-80	-60	-40	-20	LEE 0
7°	0.0015	0	-	-	-	-	-	-	-	17
↓	↓	4	79	78	-	77	-	76	-	75
7°	0.5	0	-	-	-	-	-	-	-	18
		4	44	43	-	42	-	41	-	40
↓	↓	10	68	67	107	66	108	65	109	64
10.5°/7°	0.5	0	-	-	-	-	-	-	-	90
		4	95	94	-	93	-	92	-	91
↓	↓	10	96	97	-	98	-	99	-	100

TABLE 8. TEST DATA SUMMARY - AXISYMMETRIC MODELS @ MACH 8 (CONT'D)

d. Flow Angle Sensitive Preston Tube Data

$M_\infty = 8$

Re_∞ - 3.7×10^6 FT^{-1}

B. L. TRIP - .06 IN.

MODEL CONFIGURATION			MODEL ROLL, DEG.							
CONE ANGLE	R_N IN.	α DEG.	-80	-130	-155	WIND 0	-20	-40	-60	-80
7°	.0015	0	401	-	-	-	-	-	-	-
		4	-	-	-	406	405	404	403	402
		-4	400	399	397 398	-	-	-	-	-
7°	.5	0	232	-	-	-	-	-	-	-
		4	-	-	-	233	234	235	236	237
		-4	238	239	240	-	-	-	-	-
		10	-	-	-	241	242	243	244	245
		-10	246	247	248	-	-	-	-	-
10.5°/7°	.50	0	313 347 370	-	-	-	-	-	-	-
		4	-	-	-	308 342	309 343	310 344	311 345	312 346
		-4	314 348	315 349	316 350	341	-	-	-	-
		10	-	-	-	307	306	305	304	303
		-10	355	356	357	-	-	-	-	-

TABLE 8. TEST DATA SUMMARY - AXISYMMETRIC MODELS @ MACH 8 (CONT'D)

e. Overhead Probe Survey Data

MODEL CONFIGURATION			$Re_\infty \times 10^{-6}$	α	SURVEY STATIONS (MODEL ROLL = 180 DEGREES)								
CONE ANGLE	R_N IN.	TRIP HT. (IN.)	FT^{-1}	DEG.	1	2	3	11	12	13	14	15	REMARKS
7°	.0015	.060	3.7	0	24 388* (17)	26 387* (17)	27 386* (17)						
↓	↓	↓	↓	-4	80 396* (79)	81 395* (79)	82 394* (79)						WINDWARD
↓	↓	↓	↓	+4	390 389 (75)	392 391 (75)	- 393 (75)						LEEWARD
7°	.50	.060	3.7	0	54 226* (18)	51 227* (18)	29 228* (18)						
↓	↓	↓	↓	-4	48 231* (44)	49 230* (44)	50 229* (44)						WINDWARD
↓	↓	↓	↓	+4	47 225* (40)	46 224* (40)	45 223* (40)						LEEWARD
↓	↓	↓	↓	-10	71 217* (68)	70 216* (68)	69 215 (68)						WINDWARD
↓	↓	↓	↓	+10	72 218 219 (64)	73 - 220* (64)	222 - 221 (64)						LEEWARD
7°	.50	NONE	1.0	0	19	-	-						LAMINAR
10.5°/7°	.50	.060	3.7	0				373+ (90)	372+ (90)	371+ (90)	369 (90)	368 (90)	
↓	↓	↓	↓	-4				363* 351 (95)	364* 352 (95)	365* 353 (95)	366 354 (95)	367 - (95)	WINDWARD
↓	↓	↓	↓	+4				375 374 (91)	376 - (91)	377* 302 (91)	378* 301 (91)	379* 300 (91)	LEEWARD
↓	↓	↓	↓	-10				358* 269 (96)	359* 270 (96)	360* 281 (96)	361* 282 (96)	362 (96)	WINDWARD
↓	↓	↓	↓	+10				384* 293 292 (99)	383* 295 294 (99)	382* 297 296 (99)	381* 298 - (99)	380* 299 - (99)	LEEWARD

NOTES: RUN NUMBER IN PARENTHESIS ARE SURFACE PRESSURE RUN NUMBERS ASSOCIATED WITH EACH SURVEY
*PRESTON TUBE DATA ONLY

+ SURVEY OBTAINED 1.06 IN. AFT OF SURVEY STATION

Table 8. Test Data Summary - Axisymmetric Models @ Mach 8 (Cont'd)

f. Onboard Probe Survey Data

$M_\infty = 8$
$Re_\infty = 3.7 \times 10^6\ ft^{-1}$
B.L. TRIP - .06 in.

MODEL CONFIGURATION		α DEG.	MODEL ROLL, DEG.						
CONE ANGLE	R_N IN.		-120	-95	-70	-50	-30	-10	+10 (LEE)
7^o	.0015	0							331(17)
↓	↓	4	122 334(78)		121 333(77)		120 332(76)		
7^o	.50	4	110 324 214(43)		111 323(42)		112,113 322(41)		
↓	↓	10	114 330(67)	117 329 (107)	115 328(66)	118 327 (108)	116 326(65)	119 325 (109)	
$10.5^o/7^o$	.50	0							284(90)
		4	101 287(94)		102 286(93)		103 285(92)		
↓	↓	10	104 291(97)		105 289(98)		106 288 290(99)		

NOTES: RUN NOS. < 200 → PITOT & TOTAL TEMPERATURE PROBE DATA
RUN NOS. > 200 → MACH/FLOW-ANGULARITY PROBE DATA
(RUN NOS. IN PARENTHESES ARE SURFACE PRESSURE RUN NUMBERS ASSOCIATED WITH EACH SURVEY)

3.3 Sliced Body w/o Flap - Laminar Flow: Mach 10, $\alpha \neq 0$ (References 2, 7)

The objective of this test series was to provide inputs to a laminar flow data base which will be used to validate and develop analytical codes for predicting the hypersonic aerodynamic characteristics of conic and biconic bodies with single and multiple slices (flat surfaces). The data base consists of static force data, which are documented in Reference 2, and heat transfer, surface pressure, and flow field survey data which are documented in Reference 7.

The tests were conducted in Tunnel C at a nominal Mach number of 10 and free-stream unit Reynolds numbers of 0.55 million and 1.0 million per ft. Static-stability, axial-force, and oil flow data were obtained over an angle-of-attack range was -14 to +14 deg. The effects of nose radius and single and double flat surfaces were investigated. Oil flow visualization data were acquired on the double flat surface configuration to determine the flow directions in the vicinity of the double flat surface. Static force data were obtained on both the blunted (R_N = 0.50") 7^o cone and $14^o/7^o$ bicone, and a sharp 7^o cone. The bicone data were obtained for the configuration with an axisymmetric configuration, a single windward slice cut, or a double windward slice cut.

Heat-transfer measurements were obtained over an angle-of-attack range from 0 to 14 degrees with model roll angles varying from 0 to 180 degrees. Model surface pressure and flow-field survey data were obtained at two angles of attack: 2 and 10 degrees. Flow-field instrumentation was: (1) a Mach/Flow-Angularity probe, (2) a pitot probe, and (3) a shielded total temperature probe. Surveys were taken at 17 model stations (wind and leeside) from the model surface to the bow shock. All heat-transfer, pressure and flow-field survey data were obtained on a single model configuration: a 14/7 degree biconic with a 0.5 inch radius nosetip and flats (or slices) at the model base.

The location of the Gardon-gages, pressure orifices, and the coaxial surface thermocouples on the $14^{o}/7^{o}$ bicone are listed in Tables 9a, 9b, and 9c, respectively. Shown in Figure 19 is the location of the stations where profiles were measured which includes a schematic of the surface instrument locations.

A summary of the nominal test conditions is given below:

M_∞	p_o(psia)	T_o(^oR)	q_∞(psia)	p_∞(psia)	$Re_\infty x10^{-6}$/ft
10.0	445	1900	0.70	0.009	0.55
10.0	666	1710	1.07	0.015	1.00
10.0	804	1900	1.27	0.018	1.00

Static force data were recorded in either the point-pause or sweep mode of operation, using the Model Attitude Control System.

The point-pause data were obtained for finite values of angle of attack and model roll angle with a delay before each data point to allow the base pressures to stabilize. The continuous sweep data were obtained for a fixed value of model roll angle with a sweep (α) rate of 1 deg/sec. If applicable, the base pressures were obtained from a curve fit of data obtained during the point-pause mode to calculate the base axial force coefficient.

Heat-transfer distribution data were obtained with high-sensitivity thermopile heat-flux gages. Data were taken over an angle-of-attack range from 0 to 14 degrees in one degree increments and at twenty-six different model roll angles, from 0 to 180 degrees. Prior to each run, the model was cooled to a nominal temperature of $530^{o}R$. The model attitude was preset and was then injected into the tunnel flow for about five seconds while a continuous record of gage output was recorded.

Table 9. Model Instrumentation Locations

a. Gardon Gage Locations

GAGE NO.	X_{STAG} IN.	Y IN.	GARDON Z, IN.	S IN.	ω DEG.	$(X_{APEX})_{70}$ IN.
1	2.217	0	.943	2.567	0	13.935
2	3.430		1.246	3.817		15.148
3	4.400		1.488	4.817		16.118
4	5.370		1.729	5.817		17.088
5	7.312		2.214	7.817		19.030
6	8.039		2.395	8.567		19.757
7	8.540		2.488	9.070		20.258
8	8.914		2.533	9.445		20.632
9	9.286		2.579	9.820		21.004
10	10.357		2.711	10.899		22.075
11	11.349		2.832	11.899		23.067
12	12.342		2.954	12.899		24.060
13	13.334		3.076	13.899		25.052
14	14.327		3.198	14.899		26.045
15	16.312		3.442	16.899		28.030
16	20.282		3.929	20.899		32.000
17	20.846		3.960	21.464		32.564
18	20.846	-0.933	3.888	21.464	-13.50	32.564
19	20.690	0	-3.960	21.308	180	32.408
20		1.030	-3.843	21.309	165	
21		1.990	-3.446	21.309	150	
22		2.814	-2.814	21.309	135	
23		3.446	-1.990	21.309	120	
24	20.690	3.979	0	21.309	90	32.408
25	21.783	0	3.960	22.401	0	33.500
26		-1.000	3.960	-	-14.17	
27		-1.496	3.831	22.410	-21.33	
28		-2.255	3.440	22.410	-33.25	
29		-1.000	-3.960	-	-165.83	
30		-0.750	-3.960	-	-169.28	
31		0	-3.960	22.401	180	
32		0.750	-3.960	-	169.28	
33		1.237	-3.923	22.410	162.5	
34	21.783	1.000	3.960	-	14.17	33.500
35	23.533	0	3.960	24.151	0	35.250
36	23.533	-2.131	3.767	24.174	-29.5	35.250
37	25.283	0	3.960	25.901	0	37.000
38		-1.000	3.960	-	-14.17	
39		-2.000	3.960	-	-26.80	
40		-2.606	3.721	25.937	-35	
41		-3.084	3.336	25.937	-42.75	
42	25.283	-3.934	2.272	25.937	-60	37.000
43	25.658	-0.250	3.945	-	-3.63	37.376
44	25.783	0	3.929	26.401	0	37.500
45		-1.000	3.929	-	-14.28	
46		-2.000	3.929	-	-26.98	
47		-2.525	3.851	26.440	-33.25	
48		-3.126	3.382	26.440	-42.75	
49		-3.988	2.303	26.440	-60	
50		-2.250	-3.960	-	-150.40	
51		-1.750	-3.960	-	-156.16	
52		0	-3.960	26.401	180	
53		1.000	-3.960	-	165.83	
54		1.750	-3.960	-	156.16	
55		2.474	-3.884	26.440	147.50	
56		2.250	3.960	-	29.60	
57	25.783	2.000	3.960	-	26.80	37.500
58	26.283	0	3.960	26.901	0	38.000
59	27.783	0	3.960	28.401	0	39.500
60		-1.000	3.960	-	-14.17	
61		-2.000	3.960	-	-26.80	
62		-3.292	3.561	28.455	-42.75	
63		-4.200	2.425	28.455	-60	
64		-2.625	-3.960	-	-146.46	
65		-1.750	-3.960	-	-156.16	
66		0	-3.960	28.401	180	
67		1.000	-3.960	-	165.83	
68		1.750	-3.960	-	156.16	
69		2.919	-4.113	28.455	143	
70		3.429	-3.429	28.455	135	
71		4.200	-2.425	28.455	120	
72		4.85	0	28.455	90	
73		3.000	3.960	-	37.15	
74	27.783	2.000	3.960	-	26.80	39.500
75	21.158	0	-3.960	21.776	180	32.876

TABLE 9. MODEL INSTRUMENTATION LOCATIONS (CONT'D)

b. Pressure Orifice Locations

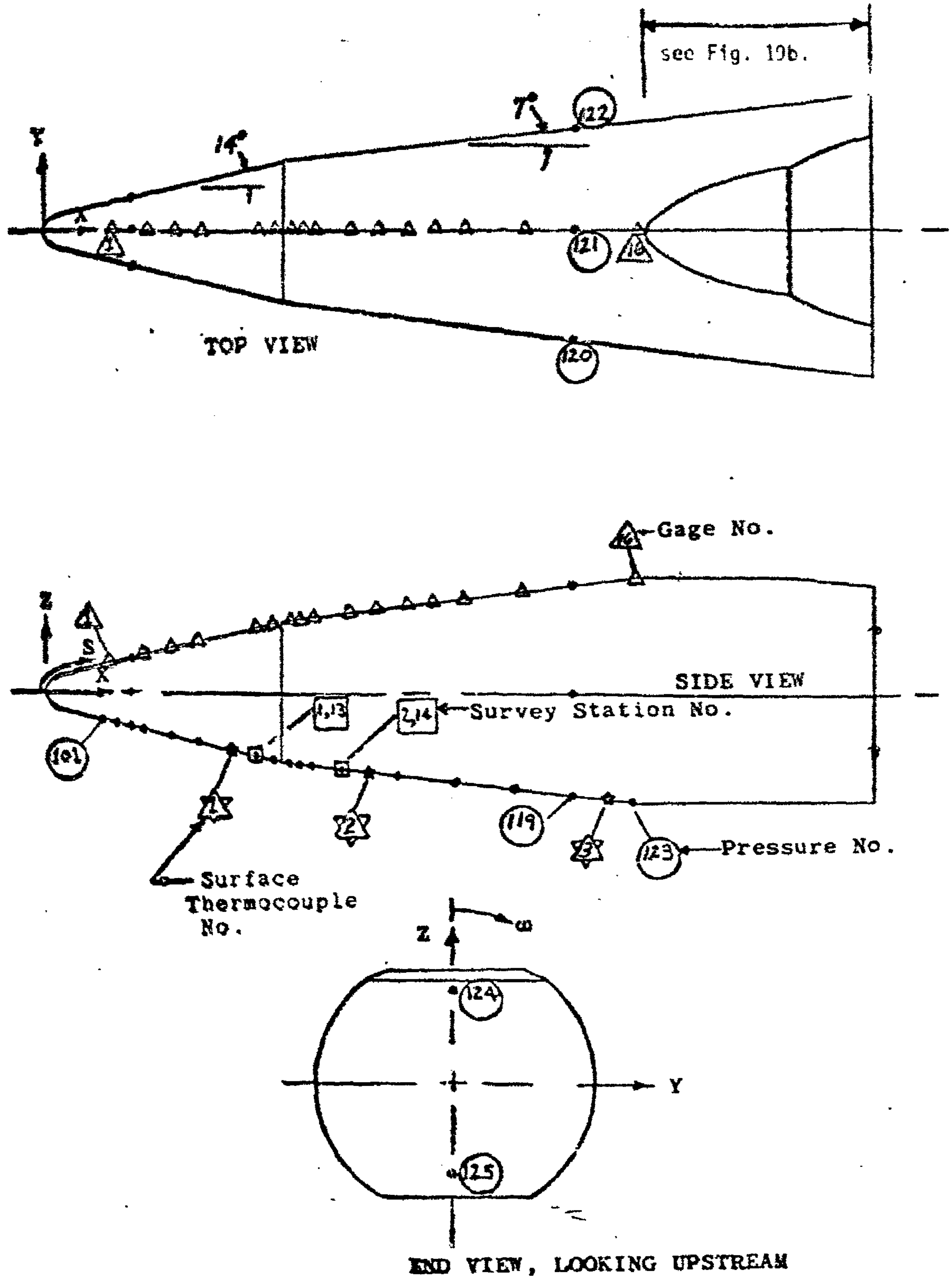
ORIFICE NO.	X_{STAG} IN.	Y IN.	Z IN.	S IN.	ω DEG.	$(X_{APEX})_{70}$ IN.
101	2.021	0	-0.894	2.355	180	17.738
102	2.506		-1.015	2.855		14.223
103	2.991		-1.136	3.355		14.708
104		-1.136	0		270	
105		0	1.136		0	
106		1.136	0		90	
107	3.476	0	-1.257	3.855	180	15.193
108	4.446		-1.499	4.855		16.163
109	5.417		-1.741	5.855		17.134
110	7.357		-2.225	7.855		19.074
111	8.085		-2.406	8.605		19.802
112	8.540		-2.488	9.070		20.257
113	8.914		-2.533	9.445		20.631
114	9.286		-2.579	9.820		21.003
115	10.357		-2.711	10.899		22.075
116	12.342		-2.954	12.899		24.059
117	14.327		-3.198	14.899		26.044
118	16.312		-3.442	16.899		28.029
119	18.297		-3.685	18.899		30.014
120		-3.685	0		270	
121		0	3.685		0	
122		3.685	0		90	
123	20.282	0	-3.929	20.899	180	31.999
124	28.283	0	1.62	-	0	40.000
125		0	-1.62	-	180	

c. Coaxial Surface Thermocouple Locations

THERMOCOUPLE NO.	X_{STAG} IN.	Y IN.	Z IN.	S IN.	ω DEG.	$(X_{APEX})_{70}$ IN.	SURVEY STATIONS
1	6.583	0	-2.032	7.057	180	18.300	1,13
2	11.283	0	-2.824	11.832	180	23.000	2,14
3	19.533	0	-3.837	20.144	180	31.250	-
4	22.408	0	-3.960	23.026	180	34.125	3,15,16
5	26.783	0	-3.960	27.401	180	38.500	17
6	24.408	0	3.960	25.026	0	36.125	-
7	27.033	0	3.761	27.663	0	38.75	6,9
8	22.658	-1.812	3.813	-	-25.42	34.375	4,5,7,8,10
9	26.783	-3.039	3.621	-	-40.00	38.500	11,12

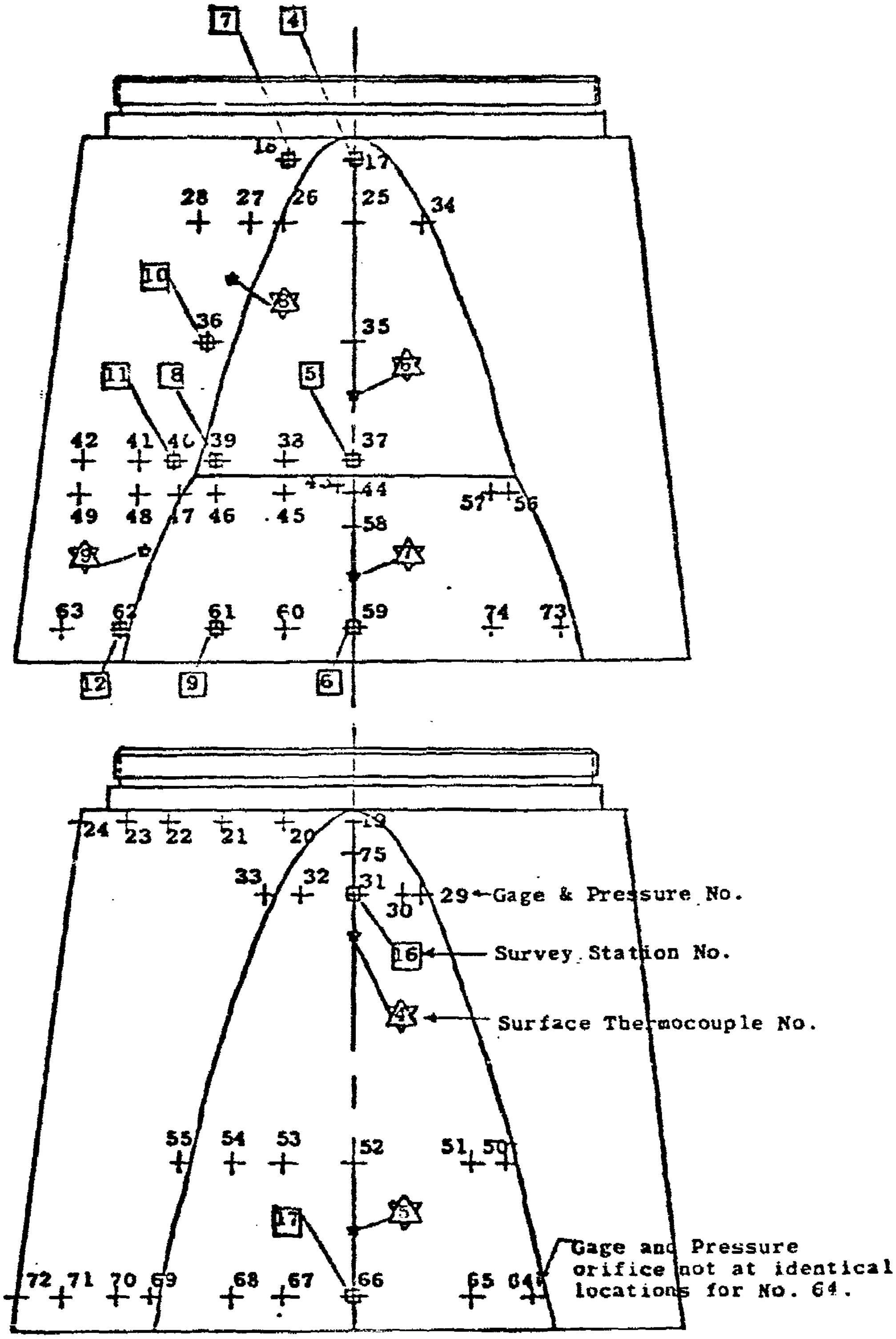
Model surface-pressure data and flow-field survey data were obtained following the heat-transfer test. Both windward and leeward surveys were made at two angles of attack, 2 and 10 degrees at 17 model locations as defined in Figures 19a and 19b. A complementary set of surface-pressure data were obtained at the same model attitudes. For these data (pressure and survey) the model was at a near equilibrium temperature condition; model wall temperatures were typically from 1000 to 1400^{o}R.

Flow-field surveys were taken from the model surface to just beyond the bow shock. A survey typically consisted of 30 to 60 data points obtained at different heights above the model surface. The three instrumentation probes used for this test were mounted in a probe holder as shown in Figure 20. Contrary to the Mach 6 tests defined in Section 3.1, and the Mach 8 tests defined in Sections 3.2 and 3.4 the Mach/Flow-Angularity probe was co-located with the Pitot and total temperature probe in this test series. The probe direction of travel was along a "surface normal" for the majority of the surveys. If it was not possible to obtain "surface normal" surveys then the surveys were made as close to the "surface normal" direction as possible and these data groups are so noted. The time required for taking the survey data was significantly reduced during this test by not waiting for the probe pressures to always reach an equilibrium condition. Rather, timewise data were recorded to provide a pressure-time history whereby the equilibrium pressure was predicted. The sequence of probe data acquisition was: (1) controller moved probe to programmed height and initiated take data, (2) data acquisition system waited a prescribed delay time (usually 3 seconds) and then recorded a specified number of data loops (15 to 30) at constant time intervals (typically 0.6 seconds) which provided time histories for each of the three transducers being scanned, (3) a valve position was changed and the sequence of "step 2) was repeated, which provided the other three pressure-time histories, (4) steps 1 through 3 repeated until all probes and passed the model bow shock.



a.) BICONIC REGION

FIGURE 19. MODEL SURFACE INSTRUMENTATION



b.) SLICED SECTION DETAILS

FIGURE 19. MODEL SURFACE INSTRUMENTATION (CONT'D)

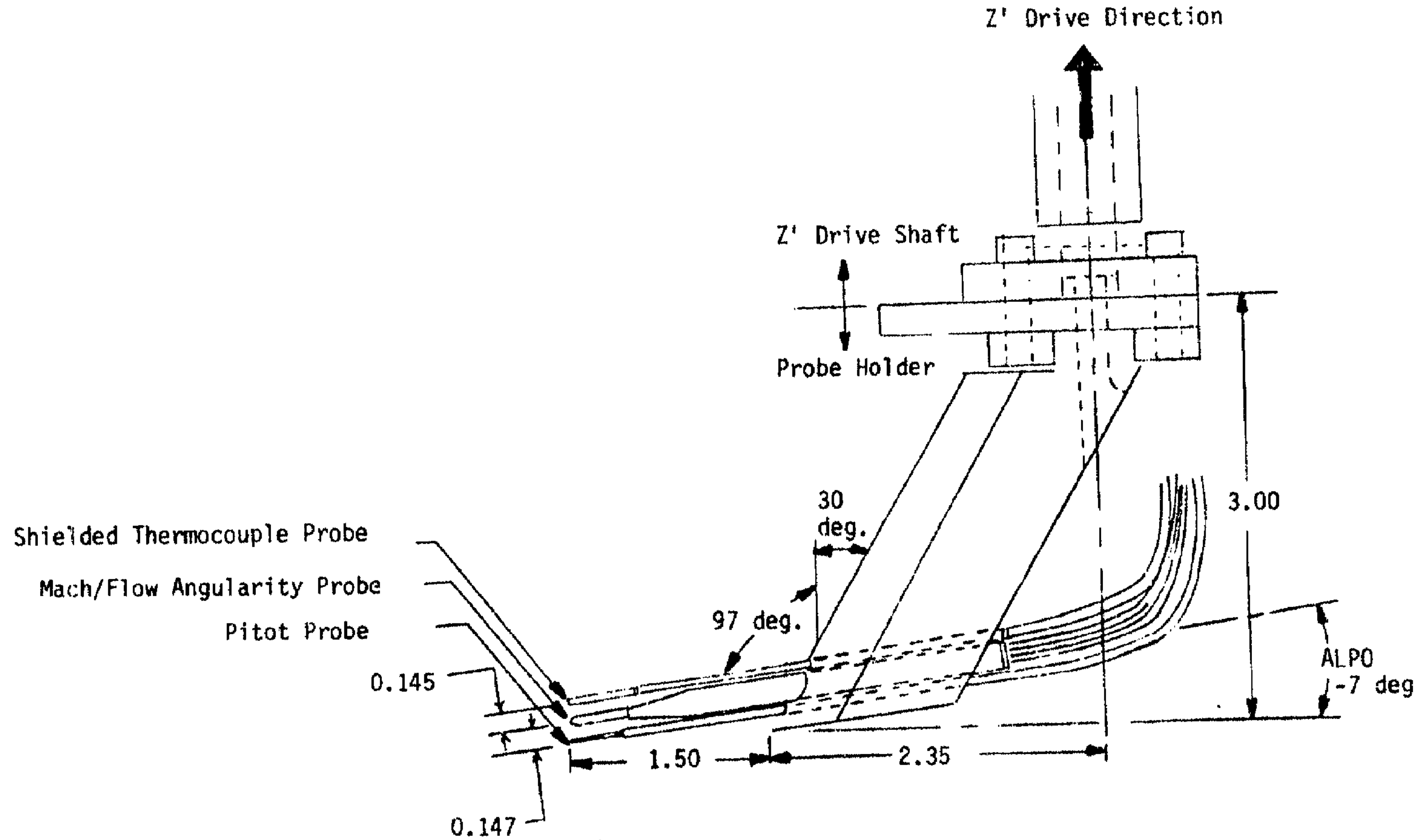


FIGURE 20. SKETCH OF FLOW-FIELD PROBES MOUNTED IN PROBE HOLDER

Probe positioning on the model surface was monitored optically. Survey axial locations (X) were verified by using a scale outline of the model overlayed on the shadowgraph system display. Survey stations (orifice locations) were marked on the outline, making it possible to position the Pitot probe over the desired pressure orifice with an estimated uncertainty of ± 0.05 in. Accurate probe positioning on the model surface was monitored optically with a back lighted high resolution (525 lines/frame) closed-circuit television (CCTV) system. The CCTV camera was fitted with a telscopic lens which gave a total magnification factor of 17. The television image was used to verify contact between the pitot probe and the model surface before obtaining the first data point in a survey. The probe spacing was measured from the photographs and included in the data reduction. Probe positioning for off-centerline stations on the 7-degree cone (SURVEY STATIONS 7, 10, 11, 12) was accomplished using a front-lighted high magnification video system.

Mach/Flow-Angularity probe calibration data were taken in the freestream at the beginning of each test shift and at the conclusion of the last test shift. Calibration data were obtained at different probe pitch attitudes, from 0 to 25 degrees.

Shielded thermocouple calibration data were obtained at the conclusion of this test series. For these data the tunnel stilling chamber pressure (P_0) was decreased in 100 psi increments from 800 to 300 psia while the total temperature was simply maintained above the air liquefaction temperature. Thermocouple probe data were recorded at each pressure level and were used to determine Reynolds number effects on the shielded thermocouple probe.

Tables 10a through 10d present the AEDC data group numbers from References 2 and 7 (and the complementary data tabulations) for each configuration tested and data type.

Table 10. Test Data Summary - Mach 10

a. Static Force Data - $Re_{\infty} = 1.0 \times 10^6$/FT

MODEL CONFIGURATION						
CONF. ANGLE	R_N (in.)	SLICE CONFIGURATION	ANGLE OF ATTACK	p_o = 666 (psia)	p_o = 804 (psia)	REMARKS
7°	0	NONE	0	-	26	BASE PRESSURE STABILIZATION STUDY
	0		-14° to +14°	-	27	SWEEP MODE
	0.50		0	-	23	POINT-PAUSE MODE
			-14° to +14°	-	24	SWEEP MODE
				-	25	POINT-PAUSE MODE
14°/7°	0.50	NONE	0	20	1	BASE PRESSURE STABILIZATION STUDY
			-14° to +14°	21	2,3,4	SWEEP MODE
				22	-	POINT-PAUSE MODE
		SINGLE WIND SLICE	0	16	5	BASE PRESSURE STABILIZATION STUDY
			-14° to +14°	17,19	6,7	SWEEP MODE
				18	8,9	POINT-PAUSE MODE
		DOUBLE WIND SLICE	0	14	10	BASE PRESSURE STABILIZATION STUDY
			-14° to +14°	15	11,12	SWEEP MODE
					13	POINT-PAUSE MODE - OIL FLOW DATA ALSO TAKEN AT α = -14,-10,2,0,2,10,14°

TABLE 10. TEST DATA SUMMARY - MACH 10 (CONT'D)

b. Heat Transfer Data

Sliced $14^{o}/7^{o}$ Bicone, R_N = 0.5"

$Re_\infty \times 10^{-6}$ FT^{-1}	ROLL ANGLE DEG.	ANGLE OF ATTACK, DEGREES 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.0	0	3,28,80,81	89	29,90	93	94	97	98	101	102	105	54,85	106	109	110	1, 86
	5	-	-	30	-	-	136	-	112	-	-	55	-	-	-	2
	10	-	-	31	-	-	137	-	113	-	-	56	-	-	-	4
	15	-	-	32	-	-	138	-	114	-	-	57	-	-	-	5
	20	-	-	33	-	-	139	-	115	-	-	58	-	-	-	6
	25	-	-	34	-	-	140	-	116	-	-	59	-	-	-	7
	30	-	-	-	-	-	141	-	117	-	-	60	-	-	-	8
	35	-	-	-	-	-	-	-	-	-	-	61	-	-	-	-
	40	-	-	36	-	-	142	-	118	-	-	62	-	-	-	10
	50	-	-	37	-	-	143	-	119	-	-	63	-	-	-	11
	60	-	-	38	-	-	144	-	120	-	-	64	-	-	-	12
	70	-	-	39	-	-	145	-	121	-	-	65	-	-	-	13
	80	-	-	40	-	-	146	-	122	-	-	66	-	-	-	14
	90	-	-	41	-	-	147	-	123	-	-	67	-	-	-	15
	100	-	-	42	-	-	148	-	135	-	-	68	-	-	-	16
	110	-	-	43	-	-	149	-	125	-	-	69	-	-	-	17
	120	-	-	44	-	-	150	-	126	-	-	70	-	-	-	18
	130	-	-	45	-	-	151	-	127	-	-	71	-	-	-	19
	140	-	-	46	-	-	152	-	128	-	-	72	-	-	-	20
	150	-	-	47	-	-	153	-	129	-	-	73	-	-	-	21
	155	-	-	48	-	-	154	-	130	-	-	74	-	-	-	22
	160	-	-	49	-	-	155	-	131	-	-	75	-	-	-	23
	165	-	-	50	-	-	156	-	132	-	-	76	-	-	-	24
	170	-	-	51	-	-	157	-	133	-	-	77	-	-	-	25
	175	-	-	52	-	-	158	-	134	-	-	78	-	-	-	26
	180	82 ,83	88	53,91	92	95	96	99	100	103	104	79,84	107	108	111	27, 87
0.55	0	159	-	160	-	-	163	-	164	-	-	167	-	-	-	168
	180	-	-	161	-	-	162	-	165	-	-	166	-	-	-	169

TABLE 10. TEST DATA SUMMARY - MACH 10 (CONT'D)

c. Model Pressure Data

$Re_\infty = 1 \times 10^6/FT$

Sliced $14^o/7^o$ Bicone, $R_N = 0.5"$

ROLL-MODEL DEG.	ANGLE OF ATTACK, DEGREES -10	-2	10
0	81	80	1609
180	-	100	-

d. Flow Field Survey Data

$Re_\infty = 1.0 \times 10^6/FT$

Sliced $14^o/7^o$ Bicone, $R_N = 0.5"$

WINDWARD SURVEYS			LEEWARD SURVEYS		
SURVEY STATION	ANGLE OF ATTACK, DEG. -2	-10	SURVEY STATION	ANGLE OF ATTACK, DEG. 2	10
1	13	-	13	14	26
2	12	23	14	15	24
3	11	22	15	16	37
4	19	28	16	17	40*
5	20	31	17	18	39*
6	21	32			
7	44*	45*			
8	35	34			
9	36	33			
10	47*	46*			
11	48*	49*			
12	51*	50*			

Notes:
- Flow-Angularity/Mach Probe calibrations: SURVEY: 7, 10, 25, 42, 52 , 53
- *Probe travel was not "surface normal" for these SURVEYS.
- Shielded thermocouple probe measurements were all outside the model boundary layer for the following SURVEYS: 11-13, 19, 22, 23, 28, 31, 33, 44-50

3.4 Sliced Body w/Flap - Turbulent Flow: $M_\infty = 8$, $\alpha \neq 0$ (References 3 and 8)

The objective of this series of tests, conducted under the MAT auspices, was to provide additional data to verify and develop computer codes to predict aerodynamic and aerothermal characteristics of maneuvering vehicles. This specific series concentrated on obtaining data on the sliced configuration with and without flaps for turbulent boundary layer conditions over an angle of attack range from 0 to 20°. The tests were conducted in Tunnel B at a nominal Mach number of 8 and a freestream unit Reynolds number of $3.7 \times 10^6/FT^{-1}$.

During this series, tests were conducted in three entries: (1) heat transfer and oil flow visualization, (2) shock layer profiles and model surface pressure, and (3) static force and moment measurements. There were two major differences between this test series and those conducted prior to this; specifically (1) the inclusion of the flaps and (2) the acquisition of data at $\alpha = 20°$. Windward and leeward surveys were obtained at several model stations, from the model surface to the bow shock, using a probing mechanism located on top of the tunnel. Flow field probes on the survey mechanism included Pitot probes, an unshielded thermocouple probe, a Preston tube and a Mach/Flow Angularity probe.

Surface pressures were measured to provide pressure data for boundary layer calculations, and heat transfer distributions were obtained to determine the boundary layer state. To provide the desired fully-developed turbulent boundary layer, a machined boundary layer trip was used for the majority of the tests. Surface shear stress data were obtained using a Preston tube attached to the probe mechanism. Model angles of attack were varied from 0 to 20 degrees and model roll angles were varied from 0 to 180 degrees. Static stability and axial force data were obtained over an angle of attack range of - 4 to 20 degrees and a sideslip angle range of -2 to 2 degrees. The effects of model nose bluntness (sharp or spherical), body geometry (sliced or unsliced), and body flap angle (0, 10, 20, or split 20/10 degrees) were investigated.

A summary of the nominal test condition for these tests is given below:

M_∞	p_0(psia)	T_0(^oR)	q_∞(psia)	p_∞(psia)	$Re_\infty \times 10^{-6}$/FT
8.0	850	1350	3.900	0.087	3.7

For the heat transfer test entry, the model was instrumented with 82 (Gardon-type) heat flux gages and for the flow field study, the model was instrumented with 88 pressure orifices and 20 coaxial surface thermocouples as shown in Figures 21 and 22. The location of the surface instrumentation is given in Table 11. After the heat transfer test entry and prior to the survey tests the Gardon gages were removed, the holes were plugged or replaced with coaxial gages and the afterbody was replaced with a pressure instrumented afterbody. The pressure orifices in the afterbody were located at the same locations as the Gardon gages, except as noted in Figure 22. The coaxial gages (surface thermocouples) were added for the survey tests to provide model surface temperature.

Three flap assemblies were used: heat transfer, full span pressure, and split pressure as depicted in Figure 23. The heat transfer flap was a full span adjustable deflection flap instrumented with nine Gardon gages. The full span pressure flap was essentially the same as the heat transfer flap except for instrumentation. The split pressure flap had fixed deflection angles of 10 and 20 degrees for its two sides and was instrumented with seven orifices and two coaxial surface thermocouples. Specific gage and orifice locations are presented in Table 12.

The nosetips used in this investigation consisted of a sharp conical nose with a radius of 0.005 inches and spherically blunted noses with radii of 0.500 inches and machined trip heights of 0.013, 0.033, and 0.060 inches (Figure 6).

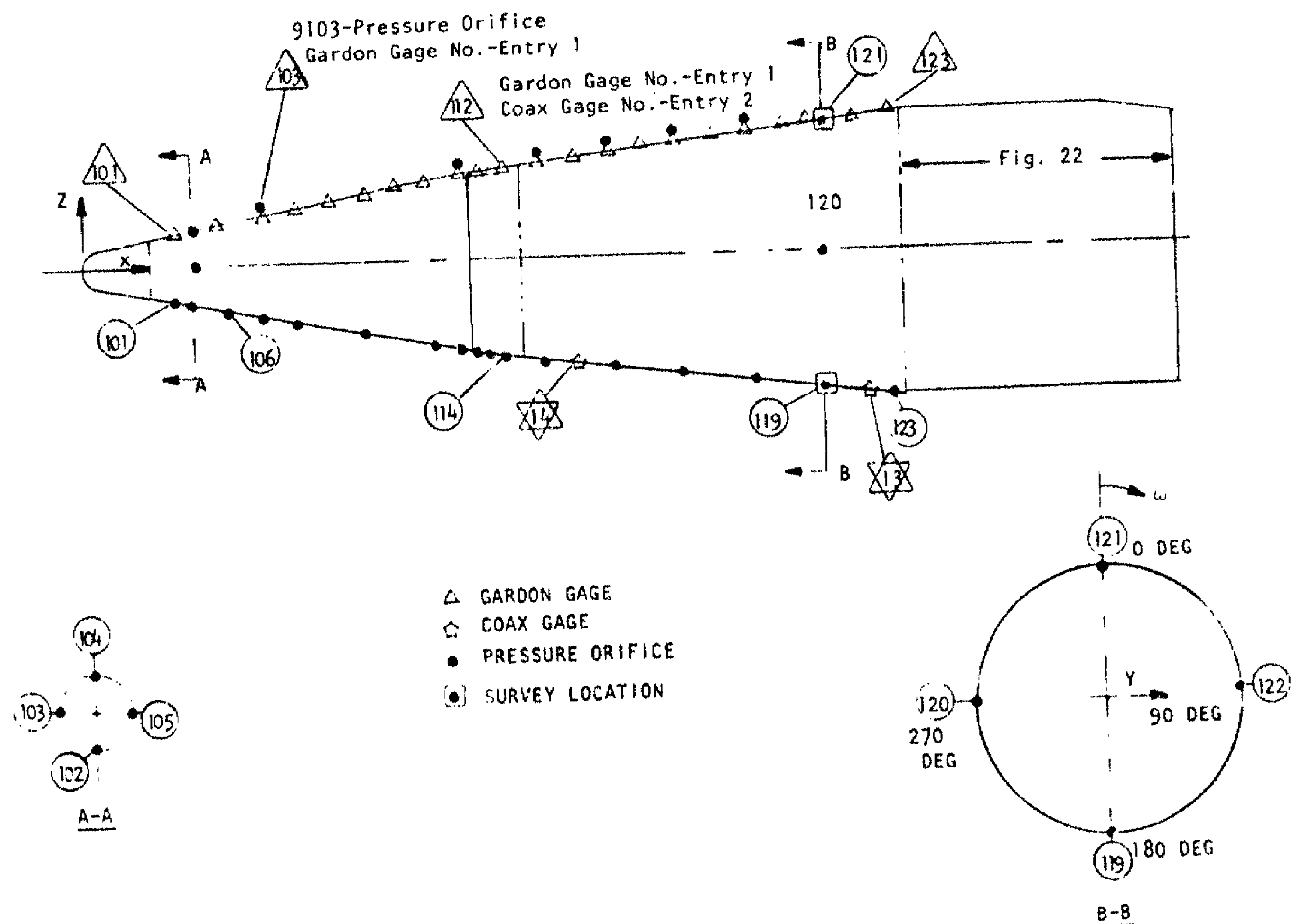


FIGURE 21. 10.5°/7° BICONIC MODEL SURFACE INSTRUMENTATION-BICONIC REGION

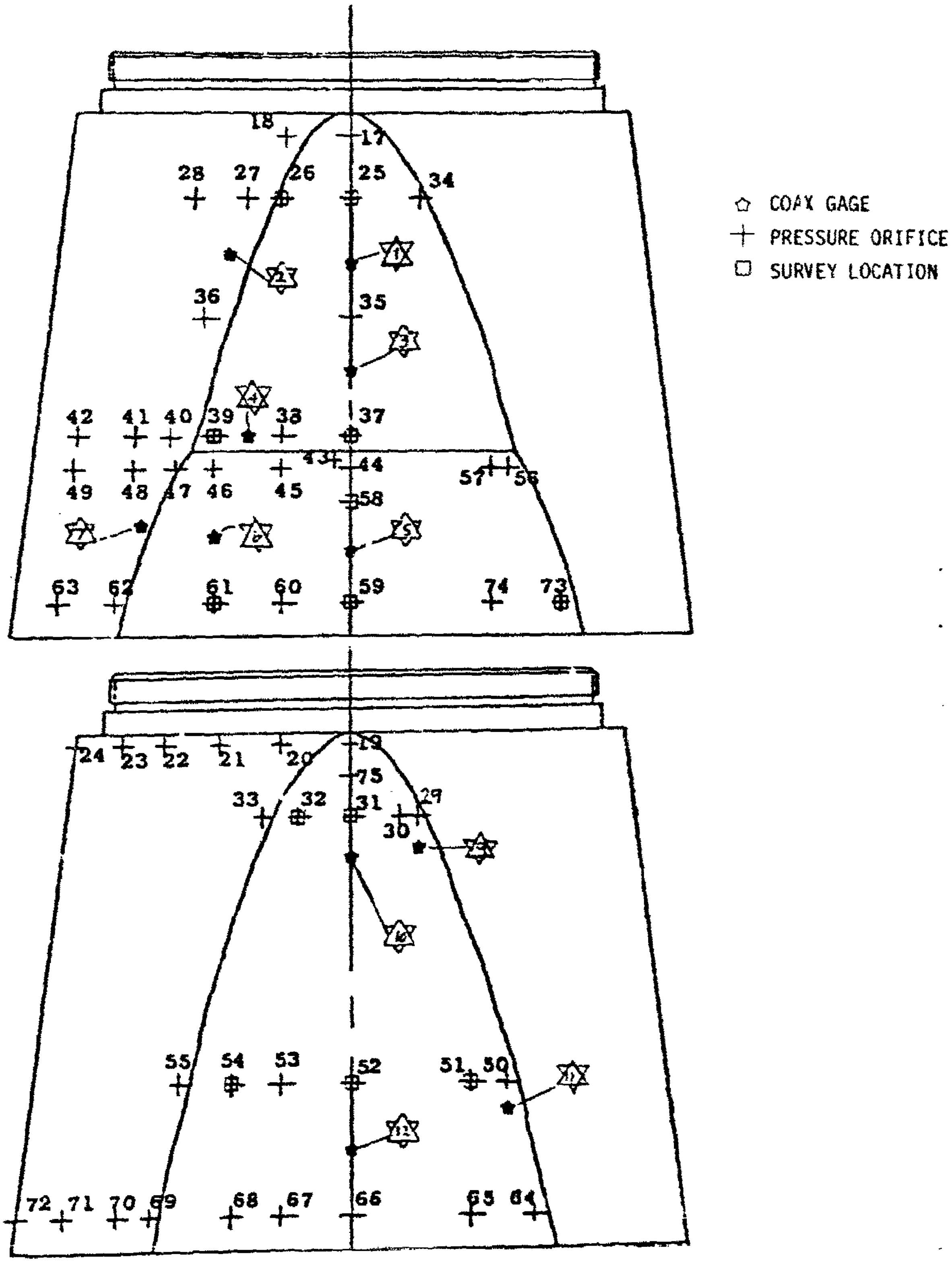


FIGURE 22. MODEL SURFACE INSTRUMENTATION, SLICED REGION DETAIL

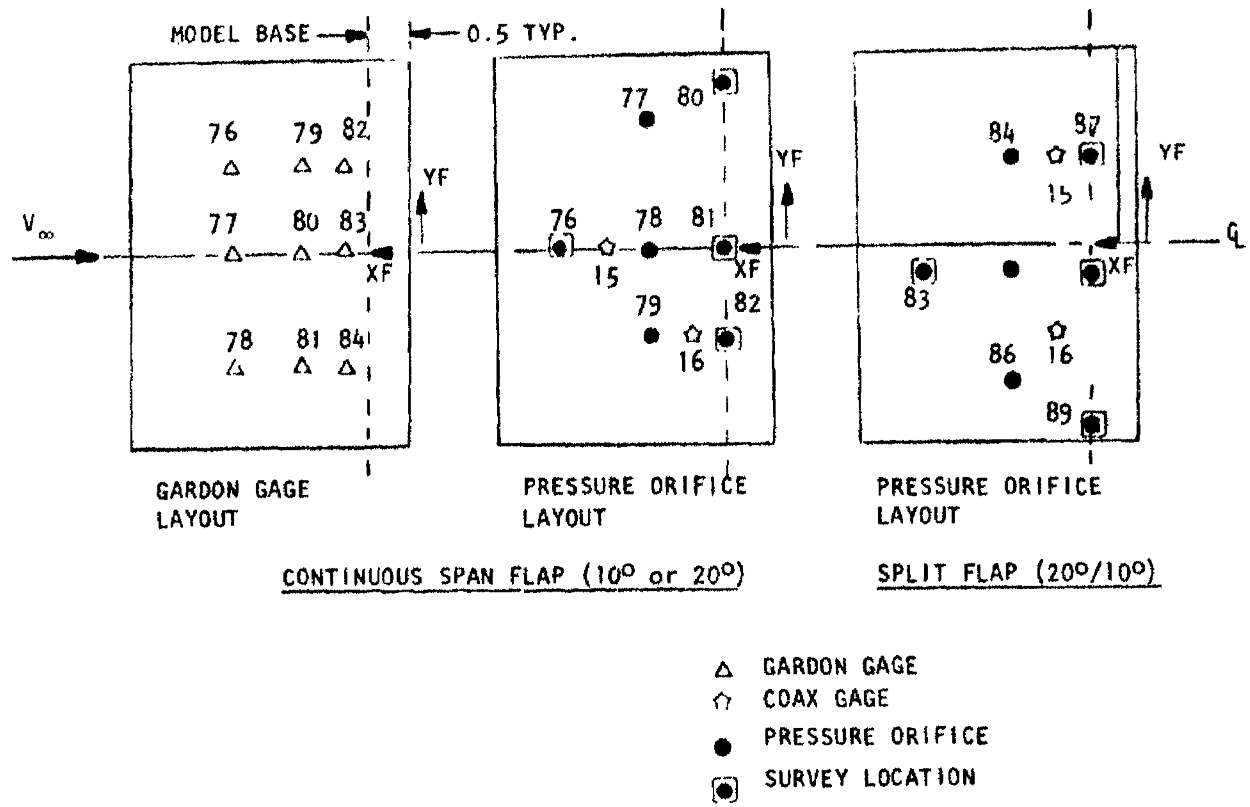


FIGURE 23. FLAP INSTRUMENTATION DETAILS

TABLE 11. MODEL INSTRUMENTATION LOCATIONS

a. Gardon and Coax Gage Locations

GARDON GAGE NO.	X, in.	Y, in.	Z, in.	S, in.	OMEGA, deg
101	2.658	0	.908	2.981	0
102	3.887		1.136	4.231	
103	5.116		1.364	5.481	
104	6.097		1.546	6.479	
105	7.080		1.728	7.479	
106	8.066		1.911	8.481	
107	8.924		2.070	9.354	
108	9.786		2.230	10.231	
109	10.770		2.412	11.231	
110	11.267		2.488	11.734	
111	11.639		2.533	12.109	
112	12.011		2.579	12.484	
113	13.082		2.711	13.563	
114	14.075		2.833	14.563	
115	15.067		2.955	15.563	
116	16.060		3.077	16.563	
117	17.052		3.198	17.563	
118	18.045		3.320	18.563	
119	19.037		3.442	19.563	
120	20.030		3.564	20.563	
121	20.725		3.649	21.263	
122	22.015		3.808	22.563	
123	23.007		3.930	23.563	

COAX GAGE NO.	X, in.	Y, in.	Z, in.	OMEGA, deg
1	25.381	0	3.960	0
2	25.381	-1.812	3.813	-25.42
3	27.131	0	3.960	0
4	28.006	-1.500	3.960	-21.15
5	29.756	0	3.620	0
6	29.506	-2.000	3.807	-28.12
7	29.506	-3.039	3.621	-40.00
9	25.006	-1.000	-3.960	-165.83
10	25.131	0	-3.960	180.00
11	29.006	-2.250	-3.960	-150.40
12	29.506	0	-3.960	180.00
13	22.256	0	-3.838	180.00
14	14.006	0	-2.824	180.00

TABLE 11. MODEL INSTRUMENTATION LOCATIONS (CONT'D)

b. Pressure Orifice Locations

PRESSURE ORIFICE NO.	X, in.	Y, in.	Z, in.	S, in.	OMEGA, deg
101	2.658	0	- .908	2.981	180
102	3.149		- .999	3.481	180
103	3.149	- .999	0	3.481	270
104	3.149	0	.999	3.481	0
105	3.149	.999	0	3.481	90
106	4.133	0	-1.182	4.481	180
107	5.116		-1.364	5.481	
108	6.099		-1.546	6.481	
109	8.066		-1.911	8.481	
110	10.032		-2.275	10.481	
111	10.770		-2.412	11.231	
112	11.267		-2.488	11.734	
113	11.639		-2.533	12.109	
114	12.011		-2.579	12.484	
115	13.082		-2.711	13.563	
116	15.067		-2.955	15.563	
117	17.052		-3.198	17.563	
118	19.037		-3.442	19.563	
119	21.022		-3.686	21.563	
120	21.022	-3.686	0	21.563	270
121	21.022	0	3.686	21.563	0
122	21.022	3.686	0	21.563	90
123	23.007	0	-3.930	23.563	180
9103	5.116		1.364	5.481	0
9109	10.770		2.412	11.231	
9113	13.082		2.711	13.563	
9115	15.067		3.077	16.563	
9117	17.052		3.198	17.563	
9119	19.037		3.442	19.563	

Table 11. Model Instrumentation Locations (Cont'd)

c. Orifice and Gardon Gage Locations

Orifice or Gage Number	X, in.	Y, in.	Z, in.	S, in.	OMEGA, deg
17	23.569	0	3.960	24.124	0
18	23.569	-0.933	3.888	24.124	-13.50
19	23.413	0	-3.960	23.968	180.00
20		1.030	-3.843	23.969	165.00
21		1.990	-3.446		150.00
22		2.814	-2.814		135.00
23		3.446	-1.990		120.00
24	23.413	3.979	0		90.00
25	24.506	0	3.960	25.061	0
26		-1.000	3.960	—	-14.17
27		-1.496	3.831	25.070	-21.33
28		-2.255	3.440	25.070	-33.25
29		-1.000	-3.960	—	-165.83
30		-0.750	-3.960	—	-169.28
31		0	-3.960	25.061	180.00
32		0.750	-3.960	—	169.28
33		1.237	-3.923	25.070	162.50
34	24.506	1.000	3.960	—	14.17
35	26.256	0	3.960	26.811	0
36	26.256	-2.131	3.767	26.834	-29.50
37	28.006	0	3.960	28.561	0
38		-1.000	3.960	—	-14.17
39		-2.000	3.960	—	-26.80
40		-2.606	3.721	28.597	-35.00
41		-3.084	3.336	28.597	-42.75
42	28.006	-3.934	2.272	28.597	-60.00
43	28.381	-0.250	3.945	—	-3.63
44	28.506	0	3.929	29.061	0
45		-1.000	3.929	—	-14.28
46		-2.000	3.929	—	-26.98
47		-2.525	3.851	29.100	-33.25
48		-3.126	3.382	29.100	-42.75
49		-3.988	2.303	29.100	-60.00
50		-2.250	-3.960	—	-150.40

TABLE 11. MODEL INSTRUMENTATION LOCATIONS (CONT'D)

c. Orifice and Gardon Gage Locations (Cont'd)

Orifice or Gage Number	X, in.	Y, in.	Z, in.	S, in.	OMEGA, deg
51	28.506	-1.750	-3.960	—	-156.16
52		0	-3.960	29.061	180.00
53		1.000	-3.960	—	165.83
54		1.750	-3.960	—	156.16
55		2.474	-3.884	29.100	147.50
56		2.250	3.929	—	29.60
57	28.506	2.000	3.929	—	26.80
58	29.006	0	3.568	29.561	0
59	30.506	0	3.684	31.061	0
60		-1.000	3.684	—	-14.17
61		-2.000	3.684	—	-26.80
62		-3.292	3.561	31.115	-42.75
63		-4.200	2.425	31.115	-60.00
64		-2.625*	-3.960	—	-146.46
65		-1.750	-3.960	—	-156.16
66		0	-3.960	31.061	180.00
67		1.000	-3.960	—	165.83
68		1.750	-3.960		156.16
69		2.919	-4.113	31.115	143.00
70		3.429	-3.429	31.115	135.00
71		4.200	-2.425	31.115	120.00
72		4.850	0	31.115	90.00
73		3.000	3.684	—	37.15
74	30.506	2.000	3.684	—	26.80
75	23.881	0	-3.960	24.436	180.00

* Y = -2.625 for Gage 64 and Y = -2.750 for Orifice 64. All others at same dimensional locations.

TABLE 12. FLAP INSTRUMENTATION LO[illegible]ONS

Pressure Flap

Orifice or Thermocouple(TG) No.	X^*, in.	XF	Y;YF, in.	δ^*, deg
76	28.995	2.50	0	10
77	29.979	1.50	1.500	
78	29.979	1.50	0	
79	29.979	1.50	-1.000	
80	30.964	0.50	2.000	
81	30.964	0.50	0	
82	30.964	0.50	-1.000	
TG15	29.487	2.00	0	
TG16	30.472	1.00	-1.000	

Heat Flap (Gardon Gage)

76	29.487	2.00	1.000	10
77	29.487	2.00	0	
78	29.487	2.00	-1.2500	
79	30.226	1.25	1.000	
80	30.226	1.25	0	
81	30.226	1.25	-1.250	
82	30.718	0.75	1.000	
83	30.718	0.75	0	
84	30.718	0.75	-1.250	

Split Flap (Pressure or TG)

83	29.995	2.50	-0.250	10
84	29.900	1.50	1.000	20
85	29.979	1.50	-0.250	10
86	29.979	1.50	-1.500	10
87	30.840	0.50	1.000	20
88	30.964	0.50	-0.250	10
89	30.964	0.50	-2.000	10
TG15	30.472	1.00	1.000	10
TG16	30.472	1.00	-1.000	20

* X locations for Heat and Pressure Flap quoted for a nominal $\delta_F = 10^o$.

The X-Y-Z overhead probe drive referred to earlier in this report was used to survey the flow field. The probe holder assemblies attached to this probe drive are illustrated in Figures 24 and 25. The flattened Pitot, upper Pitot, total temperature and Preston tube probes were mounted in one probe holder, while the Mach/Flow-Angularity probe was mounted separately. The upper Pitot was moved from 2 inches to 3 inches above the pitot, Preston, and total temperature probes, when leeward surveys were performed. It should be pointed out that in this series of tests, the Mach/Flow-Angularity measurements were made using a separate probe for a more efficient use of the tunnel since considerable delay times are required for pressure stabilization relative to the pitot pressures. For this reason, only limited Mach/Flow-Angularity data were obtained.

Probe sizes and geometries similar to those shown earlier were used in this series. The small flattened pitot and unshielded total temperature probes were used to obtain measurements close to the surface within the boundary layers and yet remain parallel to the model surface. Pitot pressure measurements were made using transducers referenced to near vacuum. The unshielded thermocouple probe had a wire junction diameter of approximately 0.007 inches. A reference dimension of 0.005 inches was used for data reduction purposes. The time response and the resolution of the probe location are improved by using such small probes. Total temperature probe uncertainties associated with the heat transfer between the probe and environment were accounted for in the freestream probe calibration (convection and conduction effects). Probe positioning in the vicinity of the model surface, probe deflections and probe spacing were measured and monitored optically with the VKF closed circuit television (CCTV) system described in Section 3.3.

Static force data were recorded in either the point-pause or sweep mode of operation using the MACS. Point-pause data were obtained for finite values of α and β with a delay before each data point to allow the base pressures to stabilize. These data were used to define the base axial force coefficient variation with angle of attack and sideslip angle.

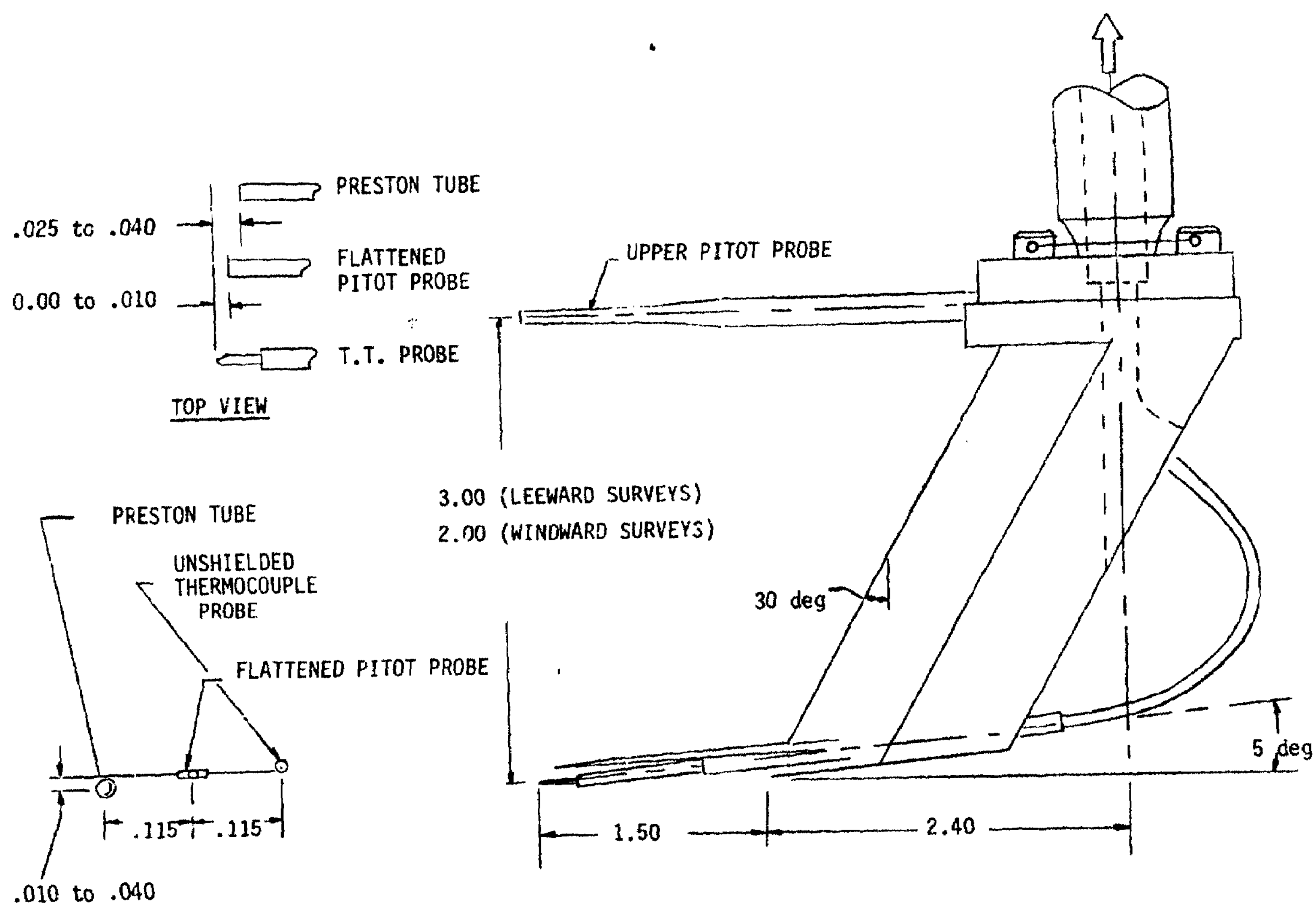


FIGURE 24. PROBE HOLDER ASSEMBLY WITH TOTAL TEMPERATURE, PITOT AND PRESTON PROBES

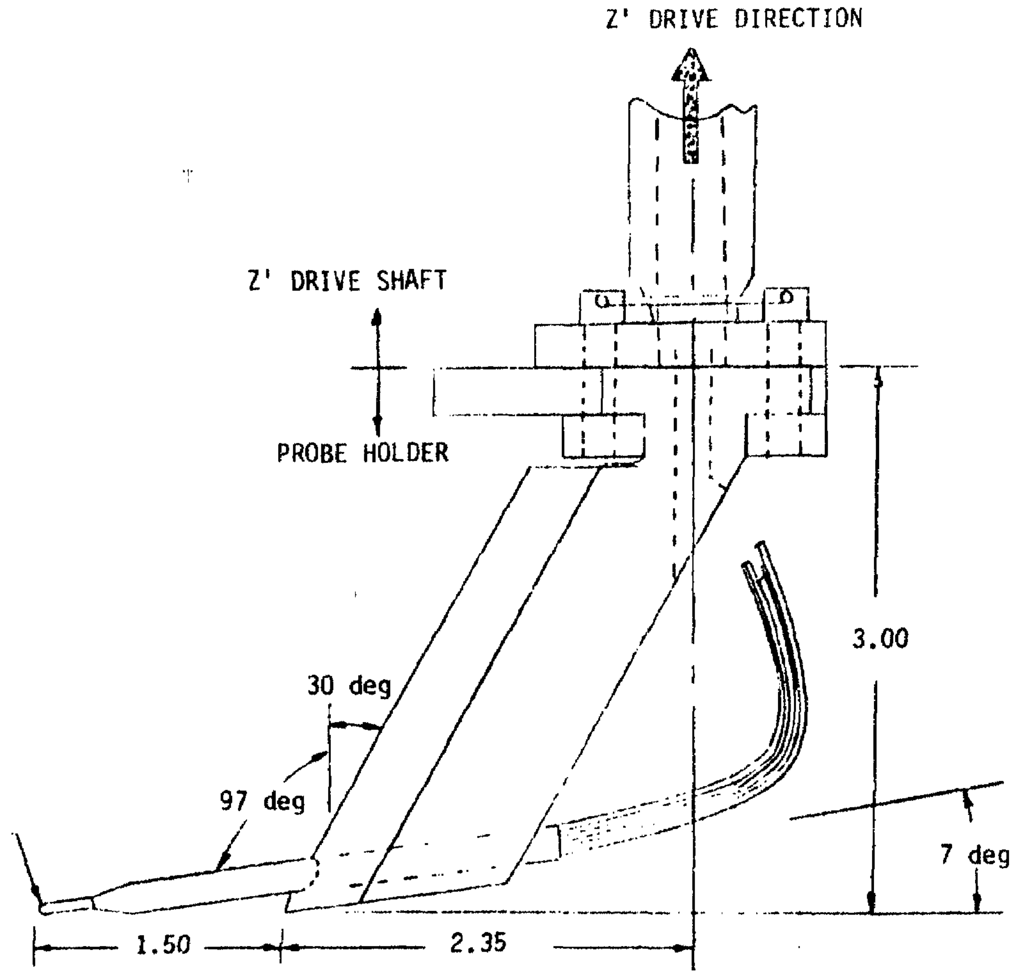


FIGURE 25. PROBE HOLDER ASSEMBLY-MACH/FLOW-ANGULARITY PROBE

These data were obtained over the model attitude range for each primary configuration and were used to provide the base axial force corrections for subsequent variations in flap deflection or for a similar configuration. The base pressure runs are identified in the test summary. The continuous sweep data were obtained for a fixed value of ϕ with a sweep rate of 1.0 deg/sec.

Data acquired during this test series consisted of (a) surface (cold wall) heat transfer, (b) oil flow and heat sensitive paint visualization, (c) surface pressure, (d) overhead probe surveys (i.e., Pitot pressure, total temperature, and Preston tube), (3) Mach/Flow Angularity calibrations, (f) total temperature probe calibrations, and (g) static force data. The procedure utilized to acquire these data were similar to those described in Sections 3.1 to 3.3 with the following two exceptions.

(1) Oil flow runs were made at the end of the heat transfer shift to visualize the flow angularity over the aft section of the model. Oil was applied and the model injected into the flow for approximately 15 seconds. Photographs of the upper and lower cut/slice regions of the model were taken at 1 frame per second.

(2) A small amount (2 RUNS) of qualitative heating data were obtained on the 10 degree flap with the phase-change paint thermal mapping technique (Reference 9). A thin sheet (0.032 inches thick) of synthetic rubber was bonded to the flap to provide an insulated surface. High heating regions were noted by observing the progression of melt (phase change) with time. The results were recorded photographically in the same manner as for oil flow.

Total temperature probe calibrations were conducted in the free-stream for each probe used. For these calibration runs, the total pressure (PT) was changed in nominal 50 psi increments from 190 to 850 psia. Total temperature probe data and tunnel conditions were recorded at each pressure level and used to determine Reynolds number effects on the unshielded total temperature probes. In addition to this Reynolds number calibration which

is built into the final data presented for the T_0 probe, the sensitivity of pitot probe and total temperature readings to flow misalignment were also obtained in the Mach 8 freestream. Data were recorded at discrete probe pitch attitudes from -22° to +10°. Contrary to the Reynolds number calibration corrections which are built into the final data T_0 tabulations, the α sensitivity data were not built into the final data since the probe misalignment at each spacial setting is not, in general, known. This will be discussed further in Section 4.

Tables 13a through 13d present the AEDC data group numbers from References 3 and 8 (along with the complementary data tabulations) for each configuration and data type.

Table 13. Test Data Summary
10.5°/7° Sliced Bicone with Flap

$M_\infty = 8 \quad Re_\infty = 3.7 \times 10^6/ft$

a. Force and Moment Data

R_N "	TRIP HT."	WINDWARD SLICES	δ^0	α^0	β^0	RUN NO.
SHARP	NONE	0°/-7°	NONE	-4 to 20	0	10
↓	↓	↓	10	-4 to 20	0	16
			20	-4 to 20	0	14,15
0.5	.060	NONE	NONE	-4 to 20	0	2,4
↓	↓	NONE	NONE	0	-4 to 20	3
0.5	.060	0°/-7°	NONE	-4 to 20	0	5,6
↓	↓	↓	↓	0	-2 to 2	7
				10	-2 to 2	8
				20	-2 to 2	9
			10	-4 to 20	0	17
			20	-4 to 20	0	11,12
			20	0	-2 to 2	13
			20/10	-4 to 20	0	18

b. Surface Pressure Data

CONFIGURATION				
R_N "	TRIP HT."	δ^0	α^0	RUN NO.
SHARP	NONE	NONE	0	79
	NONE	NONE	20	78
↓	NONE	20	0	22
0.5	.033	NONE	20	63
	.060		0	30
			10	31
↓	↓	↓	20	32
0.5	.033	10	0	1
	↓	10	4	2,
		10	10	4
	.060	20	0	23
↓	.060	20/10	0	41

TABLE 13. TEST DATA SUMMARY - (CONT'D)

10.5°/7.0° SLICED BICONE WITH FLAP

$M_\infty = 8 \quad Re_\infty = 3.7 \times 10^6/FT$

c. Heat Transfer and Oil Flow Data

				FOREBODY GAGE RAY ANGLE FROM WINDWARD, DEGREE				
				0	45	90	135	180
				MODEL ROLL, DEGREES				
R_N"	TRIP HT"	δ°	α°	0	45	90	135	180
SHARP	NONE	NONE	0	69*	-	-	-	-
↓	↓	↓	20	70*	-	-	-	-
↓	↓	10	0	36	37	38	39	40
↓	↓	↓	20	45	44	43	42	41
↓	↓	↓	SWEEP	47	-	-	-	46
0.5	0.033	NONE	0	57,62*	-	-	-	-
↓	↓	↓	4	58,63*	-	-	-	-
↓	↓	↓	10	59,64*	-	-	-	-
↓	↓	↓	20	60,65*	-	-	-	-
0.5	0.013	10	0	-	-	-	-	-
↓	↓	↓	10	26	27	28	29	30
↓	↓	↓	20	35	34	33	32	31
↓	↓	↓	SWEEP	-	-	-	-	25
0.5	0.033	10	0	2,9	-	-	-	1,8
↓	↓	↓	4	7	6	5	4	3
↓	↓	↓	10	14	15	16	17	18
↓	↓	↓	20	23	22	21	20	19
↓	↓	↓	SWEEP	-	-	-	-	24
0.5	0.060	10	0	-	-	-	-	10
↓	↓	↓	20	12	-	-	-	11,13
0.5	0.013	20	0	56	-	-	-	-
↓	↓	↓	4	55	-	-	-	-
↓	↓	↓	10	54	-	-	-	-
↓	↓	↓	20	53	-	-	-	-
0.5	0.033	20	0	75+,76+				
↓	↓	↓	0	51,52,66*	-	-	-	-
↓	↓	↓	4	50,67*	-	-	-	-
↓	↓	↓	10	49,68*	-	-	-	-
↓	↓	↓	20	48	-	-	-	-
0.5	0.033	10/20	0	71*	-	-	-	-
↓	↓	↓	4	72*,73*	-	-	-	-
↓	↓	↓	10	74*	-	-	-	-

* Indicates Oil Flow Data Run

\+ Indicates Paint Data Run

SWEEP - $10.5^\circ \geq \alpha \geq 0^\circ$

TABLE 13. TEST DATA SUMMARY - (CONT'D)

10.5°/7° SLICED BICONE WITH FLAP

$M_\infty = 8 \quad Re_\infty = 3.7 \times 10^6/FT$

d. Shock Layer Survey & Surface Shear Data

CONFIGURATION				PROFILE STATIONS																						
				FRUSTUM			SLICE 1 - WIND				SLICE 2 - WIND				LEE SLICE				FLAP			SPLIT FLAP				
	TRIP				WIND	LEE																				
R_N	H.T.(IN)	δ°	α°	118	121	119	25	26	37	39	58	59	61	73	31	32	52	54	76	81	80	83	89	88	87
SHARP	NONE	NONE	0	-	80	-	81	-	82	83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SHARP	NONE	20	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	75	76	77	-	-	-	-
0.5	.060	NONE	0	-	33	-	34	37, 214*	35, 215*	38, 216*	36	49	50	-	-	-	-	-	-	-	-	-	-	-	-
0.5	.060	NONE	10	-	51	97	52	58	53, 219*	57	54	55	56	59	91	96	92,93	94,95	-	-	-	-	-	-	-
0.5	.060	NONE	20	60 74	98,99 100	-	-	217*	218*	-	-	-	-	-	101, 102	-	103, 104	105, 106, 107	-	-	-	-	-	-	-
0.5	.033	NONE	20	-	65	-	66	72	67	71	68	69	70	-	-	-	-	-	-	-	-	-	-	-	-
0.5	.060	10	0	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16+,11 205*	12	13 207*				
0.5	.033	10	0	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17+,7	18+,9	8				
0.5	.060	10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19 209*	20	21 208*	-	-	-	-
0.5	.060	20	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24+,25 26 212*	27 28	29 213*	-	-	-	-
0.5	.060	20/10	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43 44	47	46	48

+ SURFACE SHEAR ONLY

* MACH/FLOW ANGULARITY PROBE

4.0 SHOCK LAYER SURVEY DATA REDUCTION AND PROBE CALIBRATION ISSUES

Pitot pressure and total temperature probes are sensitive to flow alignment, and consequently were calibrated for this effect during the course of this investigation. In addition, the unshielded total temperature probes are also Reynolds number dependent and therefore, as mentioned in Section 3, were also calibrated for this effect. In this section, the probe calibrations will be discussed and summary highlights of these results will be presented.

During the course of those experiements which predated the MAT program, data reduction procedures were established to not only provide probe corrections to the data but also to define local state variables in the boundary layer and the entire shock layer. To perform this boundary layer type analysis the assumption was made that the static pressure along a line normal to the wall is constant throughout the shock layer. This assumption is not correct outside the boundary layer and leads to incorrect properties in the shock outside the boundary layer. This will also be discussed in this section.

4.1 Unshielded Total Temperature Probe Reynolds Number Correction

The total temperature measurements in the shock layer were generally made with an unshielded total temperature probe. The probe was constructed from 0.010 inch O.D. sheathed thermocouple housing with 0.0015 inch diameter wires. The junction formed by joining the two wires together was nominally 0.005 inches in diameter. The unshielded total temperature probe was calibrated in the freestream to provide a recovery factor, η, as a function of Reynolds number, as defined by

$$\frac{T_{o_c}}{T_{o_m}} = \frac{1 + \frac{\gamma-1}{2} M^2}{1 + \frac{\gamma-1}{2} \eta M^2}$$

where $\eta = a_0 + a_1 Re_0^{1/2}$. Here, M is the local Mach number, γ is the specific heat ratio, a_0 and a_1 are calibration constants, Re_0 is the local Reynolds number with viscosity based on the total temperature, T_{0_c}, and T_{0_c}/T_{0_m} is the ratio of the corrected to measured total temperature. The calibration given in the equation above is discussed by Varner (Reference 17) and is compatible with the correlation for cylinders in incompressible flow as defined in Reference 18.

It should be noted that the calibration η vs. $Re_0^{1/2}$ is probe specific and consequently was performed in each test series and was frequently repeated with a given probe, for verification. Shown in Figure 26 is a representative total temperature probe calibration which was obtained with the probe in the freestream and which was used to define the constants a_0 and a_1. Although this calibration was obtained at one value of Mach number, earlier results were obtained at several M_∞'s from 1.5 to 6, and the results could be expressed adequately by a simple T_0 variation, as shown. This correction is built into the final data package and permits the iterative correction of (TTLU) to (TTL), i.e., the uncorrected to corrected total temperature. Throughout each test series one will find data groups defining where these calibrations were performed and the groups which were affected by each calibration. A representative listing from the MAT program test series is shown in Table 14.

4.2 Angle-of-Attack Probe Calibrations

It is well known that flow field survey measurements are sensitive to each probe's alignment with the flow. Consequently the probes used in the current test series were periodically calibrated in the freestream as a function of ALPT or angle of attack. Shown in Figure 27 is a typical α calibration of the Pitot and total temperature probes taken over a 26^0 range in ALPT. Results from these tests indicate that these α calibrations are peculiar to each probe. Hence α calibrations were periodically performed, especially when the probe tip was changed, for whatever reason. For measurements taken in the shock layer, where the probe tip was nominally aligned parallel to the local model surface, the probe becomes misaligned with

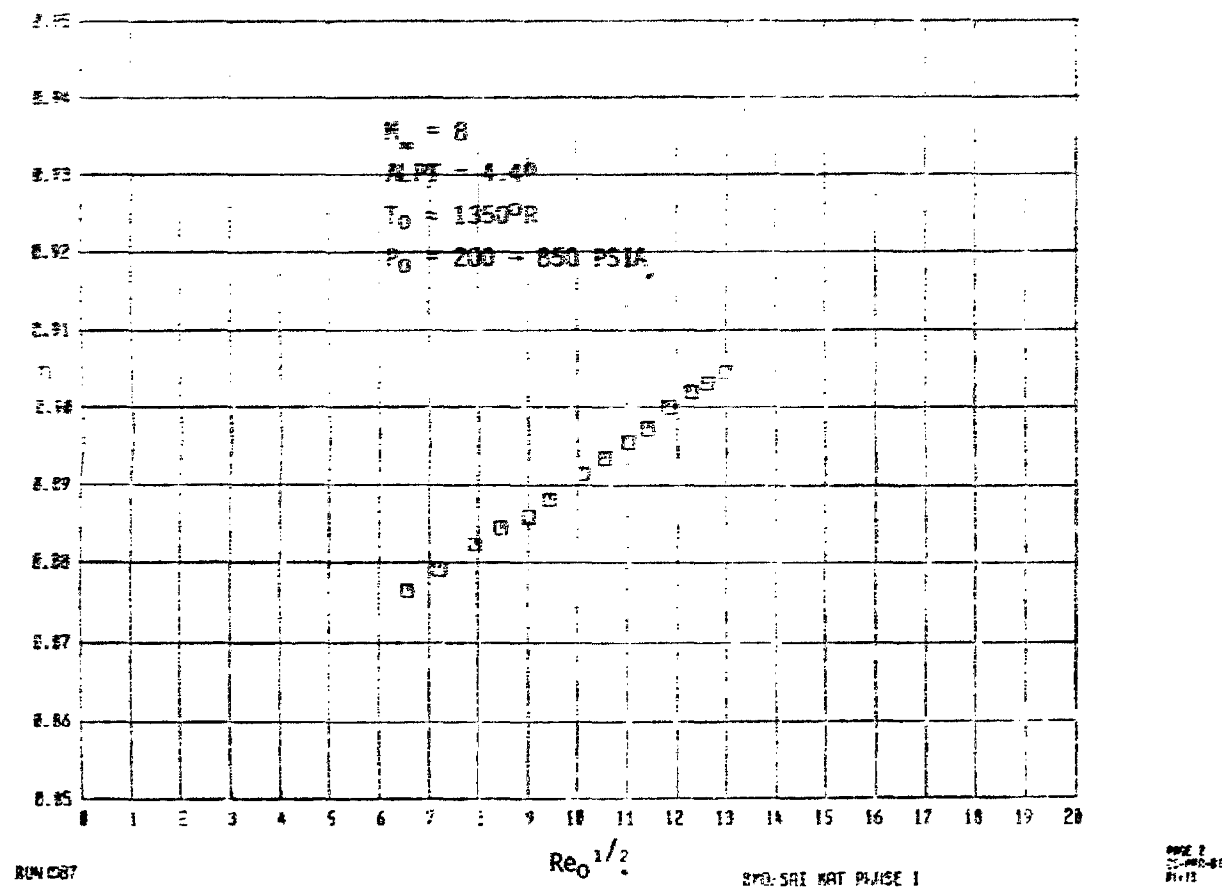


FIGURE 26. REPRESENTATIVE TOTAL TEMPERATURE PROBE CALIBRATION

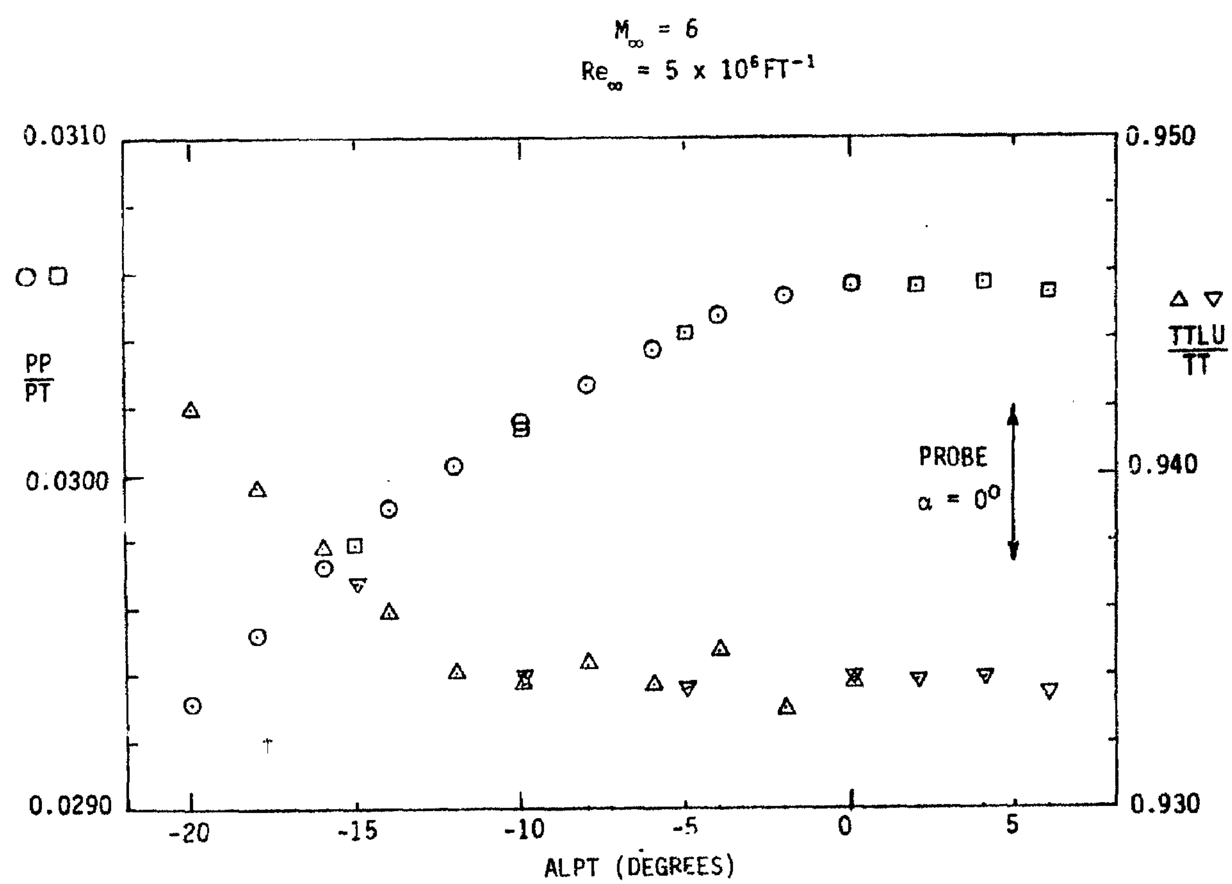


FIGURE 27. REPRESENTATIVE PITOT AND TOTAL TEMPERATURE PROBE CALIBRATION WITH α

TABLE 14. TOTAL TEMPERATURE PROBE CALIBRATION DATA FROM THE MAT PROGRAM TEST PHASE

RUN	PT, psia	REMARKS
5	500 → 850	ALPT = 0 USED IN OBTAINING CURVE FIT FOR RUNS 5 → 39
14	350 → 850	ALPT = 0 USED IN OBTAINING CURVE FIT FOR RUNS 5 → 39
15	550 → 850	ALPT = 0 USED IN OBTAINING CURVE FIT FOR RUNS 5 → 39
39	187 → 853	ALPT = 0 USED IN OBTAINING CURVE FIT FOR RUNS 5 → 39
40	550 → 850	ALPT = 0 USED IN OBTAINING CURVE FIT FOR RUNS 40 → 44
61	200 → 850	ALPT = 0 DEG USED IN OBTAINING CURVE FIT FOR RUNS 45 → 61
62	570 → 850	ALPT = 0 DEG USED IN OBTAINING CURVE FIT FOR RUNS 62 → 87
73	850	10 > ALPT > -20 DEG USED TO NOTE EFFECT OF ANGLE OF ATTACK ON PROBE OUTPUT
87	200 → 850	ALPT = 4.4 DEG USED IN OBTAINING CURVE FIT FOR RUNS 62 → 87
88	553 → 850	ALPT = 0 DEG USED IN OBTAINING CURVE FIT FOR RUNS 88 → 108
108	300 → 804	ALPT = 0 DEG USED IN OBTAINING CURVE FIT FOR RUNS 88 → 108

the local flow as it is incremented away from the model surface. When the probe penetrates the bow shock the misalignment is greatest.

Since the flow direction in the shock layer is, in general, unknown one cannot readily apply this probe α correction to the data. Consequently the published data from the entire bicone test series does not contain this correction. Scanning the results of the several probe calibrations indicates that the ratio (PP/PT) varies by 3-5% for $\alpha = 0 \rightarrow 20^{0}$ and that the ratio (TTLU/TT) varies by 1-6% in this same α range. These errors can affect the deduced Mach number by $\sim \pm 0.2$ at $M > 7$ and less than ± 0.1 at $M < 4$.

As stated above, since the flow direction at an arbitrary point in the shock layer is unknown, a priori, the following recommendation for the use of this α calibration is suggested. Since one of the primary objectives of acquiring these data is to validate detailed computer codes (i.e., PNS or Inviscid), and since the orientation of the probe is known, a correction can be made on a point by point basis by defining the probe misalignment using the theory to define the "true" flow direction (clearly an assumption). Using this value of $\Delta\alpha$, a correction can be made. The validity of this assumption can be ascertained by utilizing the limited quantity of Mach/Flow-Angularity data. One notes that this correction is not significant, consequently this procedure should be more than adequate.

4.3 Boundary Layer Type-Data Reduction

In general, the preponderance of shock layer profile data consisted of measuring the local Pitot pressure and total temperature at various points from the model surface to the bow shock, and slightly beyond. The authors strongly recommend that comparisons of theory and data be made by directly comparing the experimentally measured Pitot pressure (normalized by P_{T_∞}) and Reynolds number corrected total temperature (also normalized, here with T_{0_∞}) with values deduced numerically. That is, in the numerical simulations, all of the local state variables are known, consequently one can readily define (PP/PT) and (TTL/TT). No assumptions are required. The inverse is

not true however; that is, if one wishes to define the local state variables from the experimental data one must invoke critical assumptions since the local static pressure in the shock layer is unknown, only the wall value is known. Shown in Figure 28 are the static pressure profiles computed for a blunted 7° cone with the parabolized Navier-Stokes (PNS) solution of Reference 19. This figure presents the normalized static pressure profile versus a normalized shock layer thickness. One will note that the classical assumption that $\partial p/\partial y$ in the boundary layer is zero is quite valid here. However gradients exist outside of the boundary layer and consequently the constant P_W assumption in the shock layer is poor. To further illustrate that large static pressure gradients exist in the shock layer, PNS calculations were also made in the flap region for the $10.5^{\circ}/7^{\circ}$ bicone, for $M_{\infty} = 8$, $\alpha = 0^{\circ}$, and $\delta = 10^{\circ}$ (Figure 29). Rather dramatic departures from the wall static pressure are seen through the shock layer.

Nevertheless the final data reduction performed at AEDC used the local values of PP and TTL in concert with the local wall static pressure (assumed to be constant in the shock layer) to deduce the state variables. That is, from P_W and PP one can deduce M; than with M and TTL known one can deduce the local T, etc. Although this analysis was performed throughout the shock layer, it is clearly valid only in the boundary layer, and the final results therein can be used with confidence. Shown in Figure 30 is a sample of the final reduced data made using this constant P_W assumption. Values of M_L and u_L defined at ZP < 0.18" are clearly valid, however values beyond this point are incorrect. One notes, for example, that beyond the bow shock in the freestream $M_L/M_e = 0.6$ and $u_L/u_E \approx 0.83$.

In this post test analysis procedure, the viscous layer thicknesses were also deduced from the measured data. This analysis was based on the experimental definition of the boundary layer thickness. For these tests it must be based on the character of the total temperature profile rather than the velocity profile. That is, for blunted bodies, in regions of entropy layer swallowing, velocity gradients exist at the boundary layer edge rendering this method of defining δ intractable. The total temperature can be used to define the boundary layer thickness, albeit the thermal thickness and not the classical velocity thickness as illustrated below.

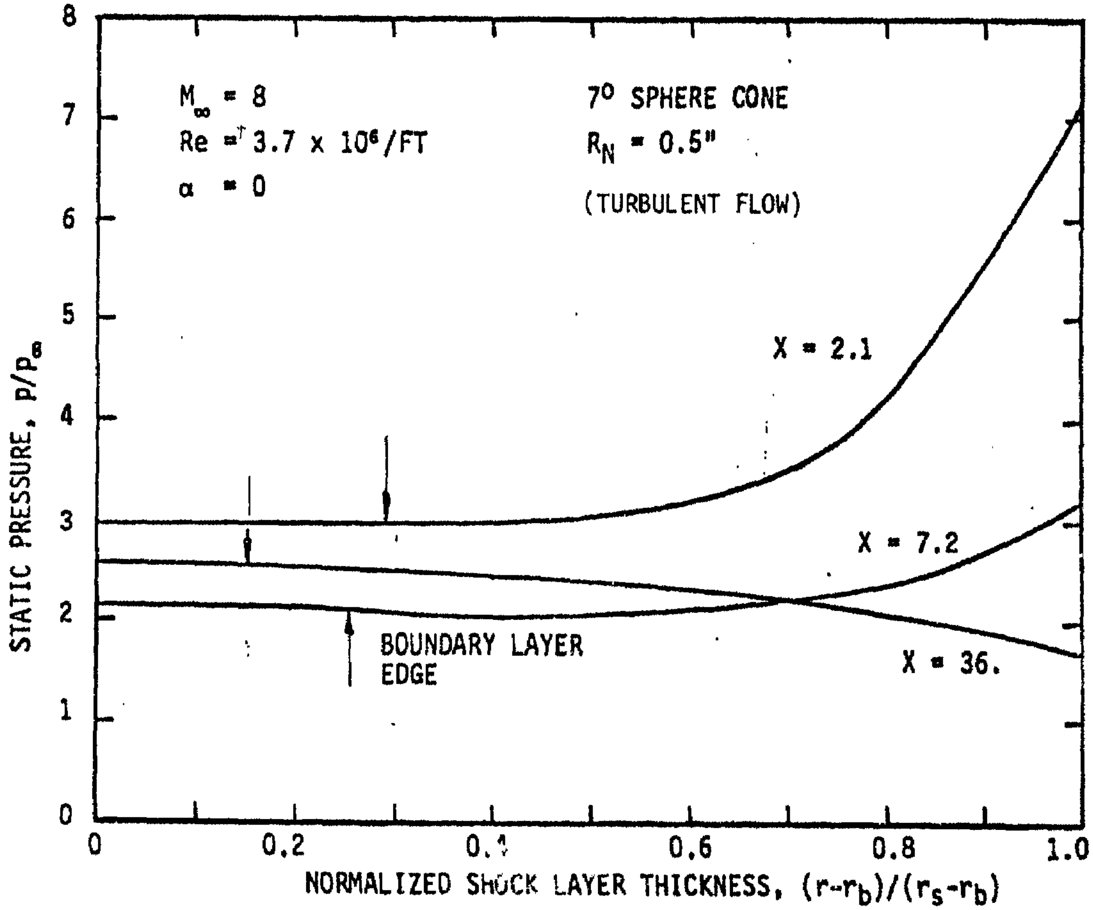


FIGURE 28. STATIC PRESSURE DISTRIBUTIONS THROUGH THE SHOCK LAYER

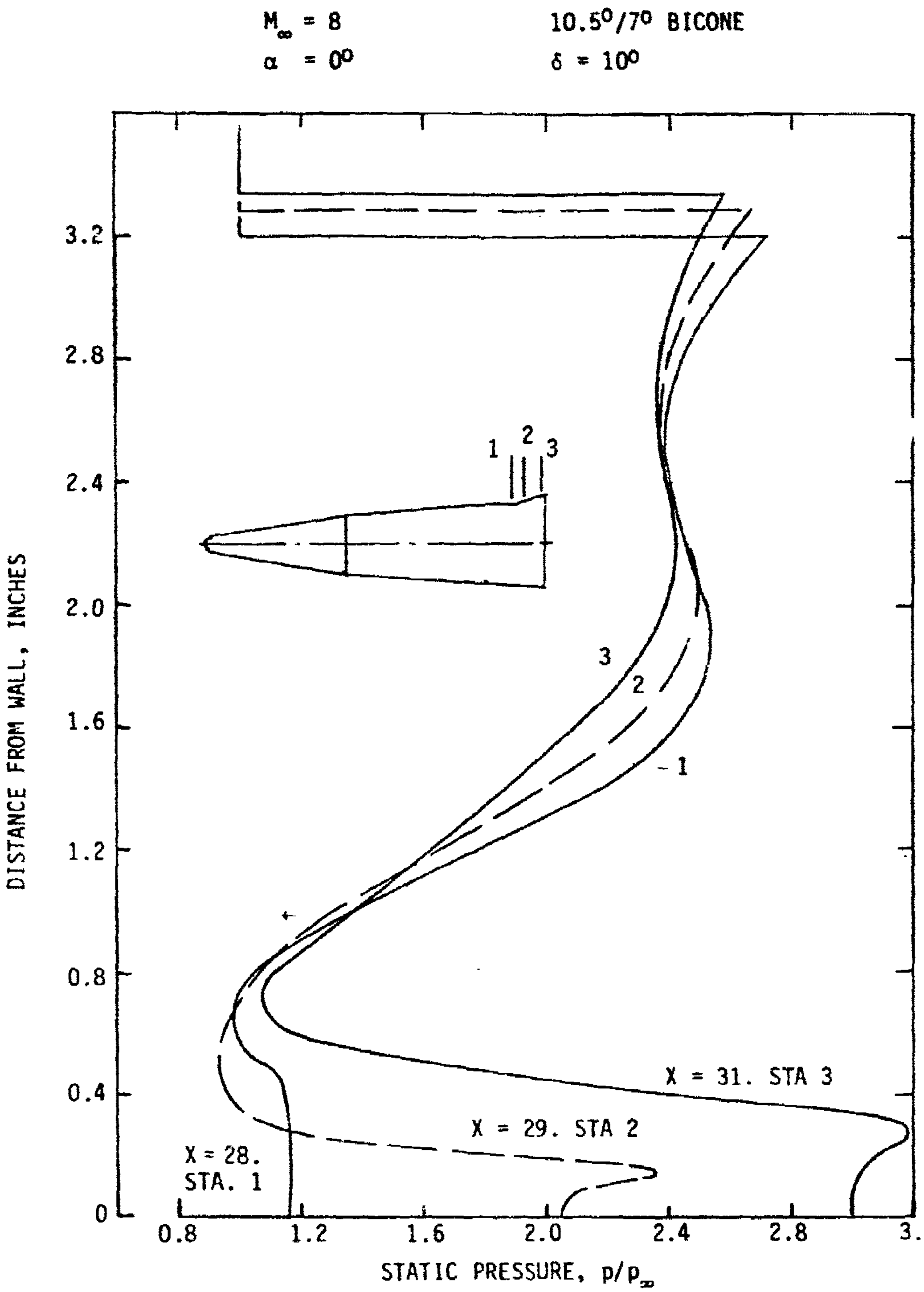


FIGURE 29. PNS PREDICTED FLAP REGION STATIC PRESSURE PROFILES THROUGH THE SHOCK LAYER

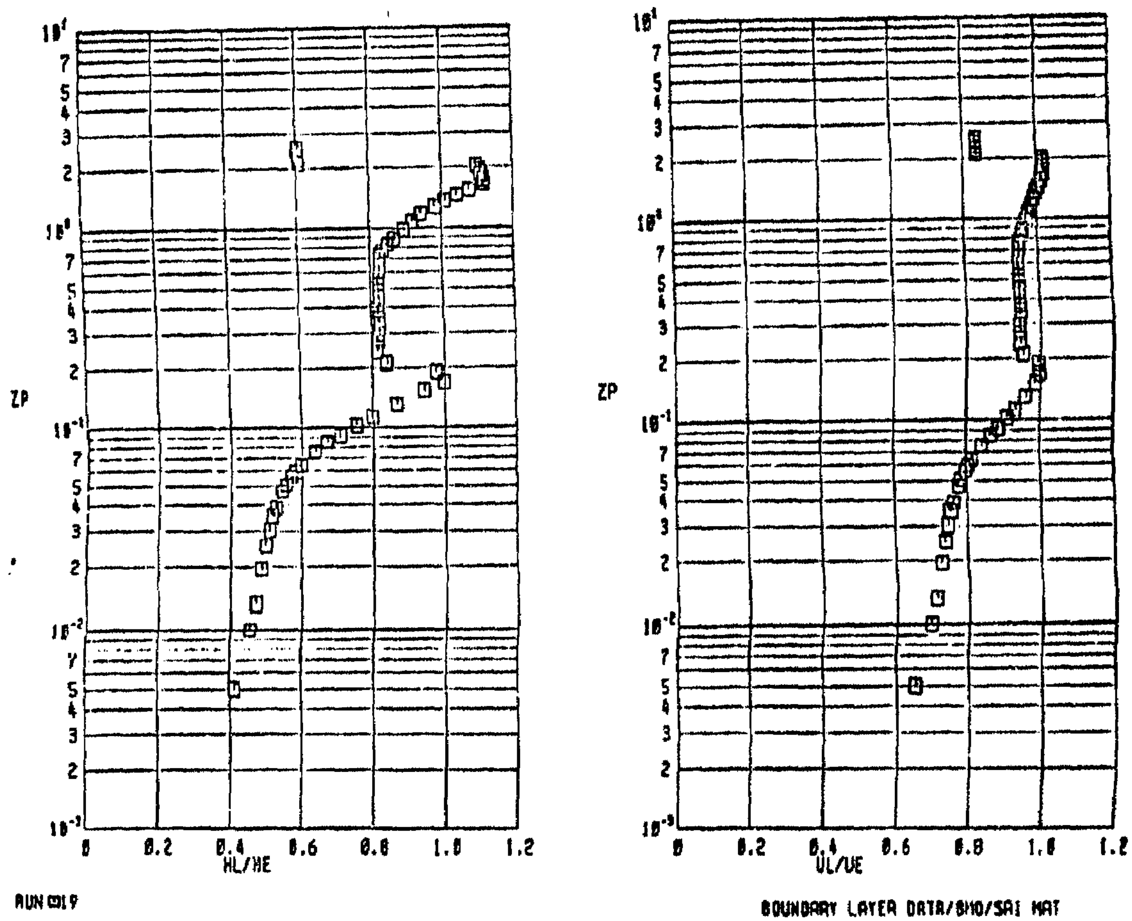
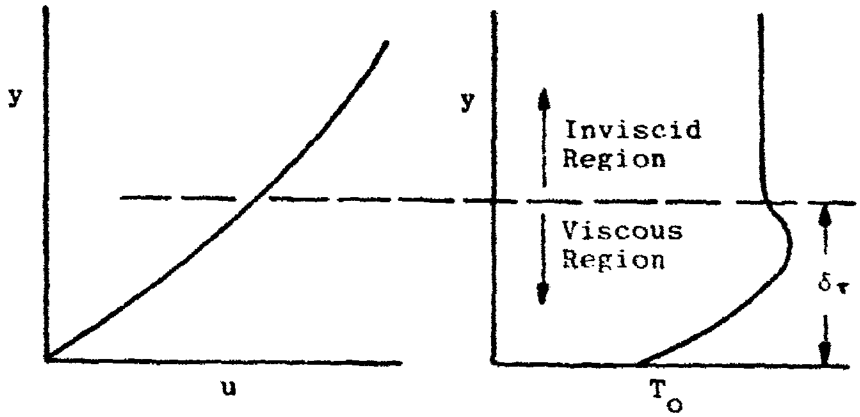


FIGURE 30. ILLUSTRATIVE EXAMPLE OF REDUCED 'HYTAC' DATA - 10.5°/7° BICONE

$\alpha = -10^\circ$, $\delta_F = 10^\circ$, STATION 76



In the data analysis at AEDC, the boundary layer thickness is defined as that distance above the model surface where the total temperature attains a value of either 0.9975 T_{o_∞} for profiles with no overshoot or 1.0025 T_{o_∞} for profiles with a significant overshoot. Based on the boundary layer thickness defined in this manner, the displacement, momentum, kinetic energy, and total enthalpy thicknesses (δ^*, θ, δ_3, and δ_4, respectively) are also presented. These thickness parameters have a well-defined physical interpretation only for flows in which the velocity asymptotes to a constant edge value (i.e., sharp cone flow). Based on a well-defined boundary layer edge condition, they are, however, mathematically unique and can provide additional insight into interpretation of local flow field behavior especially if one is comparing results to boundary layer formulations. The thicknesses are defined as follows:

$$\delta^* + \frac{\cos\theta_c}{2 r_w}\,\delta^{*2} = \int_0^{\delta_T}\left(1 - \frac{\rho u}{\rho_e u_e}\right)\left(1 + \frac{y}{r_w}\cos\theta_c\right)dy$$

$$\theta + \frac{\cos\theta_c}{2 r_w}\,\theta^2 = \int_0^{\delta_T}\frac{\rho u}{\rho_e u_e}\left(1 - \frac{u}{u_e}\right)\left(1 + \frac{y}{r_w}\cos\theta_c\right)dy$$

$$\delta_3 + \frac{\cos\theta_c}{2 r_w}\,\delta_3^2 = \int_0^{\delta_T}\frac{\rho u}{\rho_e u_e}\left[1 - \left(\frac{u}{u_e}\right)^2\right]\left(1 + \frac{y}{r_w}\cos\theta_c\right)dy$$

$$\delta_4 + \frac{\cos\theta_c}{2 r_w}\,\delta_4^2 = \int_0^{\delta_T}\frac{\rho u}{\rho_e u_e}\left(1 - \frac{T_o}{T_{o_e}}\right)\left(1 + \frac{y}{r_w}\cos\theta_c\right)dy$$

where θ_c is the local cone angle and r_w is the body radius measured normal to the model centerline. Shown in the Appendix is an example of the complete results of this boundary layer analysis. For each of the tests performed in this test series, that is both those conducted prior to the MAT program and in the MAT program tests, this post test analysis was performed and the results were tabulated and plotted.

5.0 TEST DATA HIGHLIGHTS

During the course of this experimental investigation, a considerable body of data were obtained on the sharp and blunt 7^0 cone and two bicone configurations (i.e., $10.5^0/7^0$ and $14^0/7^0$). The latter test series focused on the acquisition of data in the slice and flap regions. Body surface and shock layer profile data were obtained for laminar and turbulent flow conditions. To promote turbulence on the model for the Mach 8 conditions with the R_N = 0.5" nose, boundary layer trips were used. Some highlights of the trip investigation results will be presented here. In addition, two of the primary contributions provided in the last test series sponsored by the MAT program were the $\alpha = 20^0$ sliced bicone data and the flap data. Consequently, highlights of these results also will be presented here.

5.1 Boundary Layer Trip Effectiveness

Boundary layer trips were required in order to promote a turbulent boundary layer for the configuration with a nose radius of 0.50 inches. Shown in Figure 31 is the axial distribution of surface heat transfer obtained at Mach 8 and $\alpha = 0^0$ on the blunted $10.5^0/7^0$ bicone for three trip geometries. Also shown is a turbulent boundary layer prediction obtained with the finite difference boundary layer code of Reference 20. It is evident from this figure that the flow remains laminar with the 13 mil trip, is transitional on the 10.5^0 forecone for the 33 mil trip and is turbulent at the roughness site with the 60 mil trip. It should be noted that the data shown here were obtained at a model wall temperature of 560^0R. It was found (although not shown here) that the boundary layer profile obtained at the reference survey station at $\alpha = 0^0$ and at an equilibrium wall temperature of nominally 1100^0R was laminar-transitional when the 33 mil trip was used and turbulent for the 60 mil trip. Consequently, these data indicate that boundary layer trip effectiveness is dependent on the wall

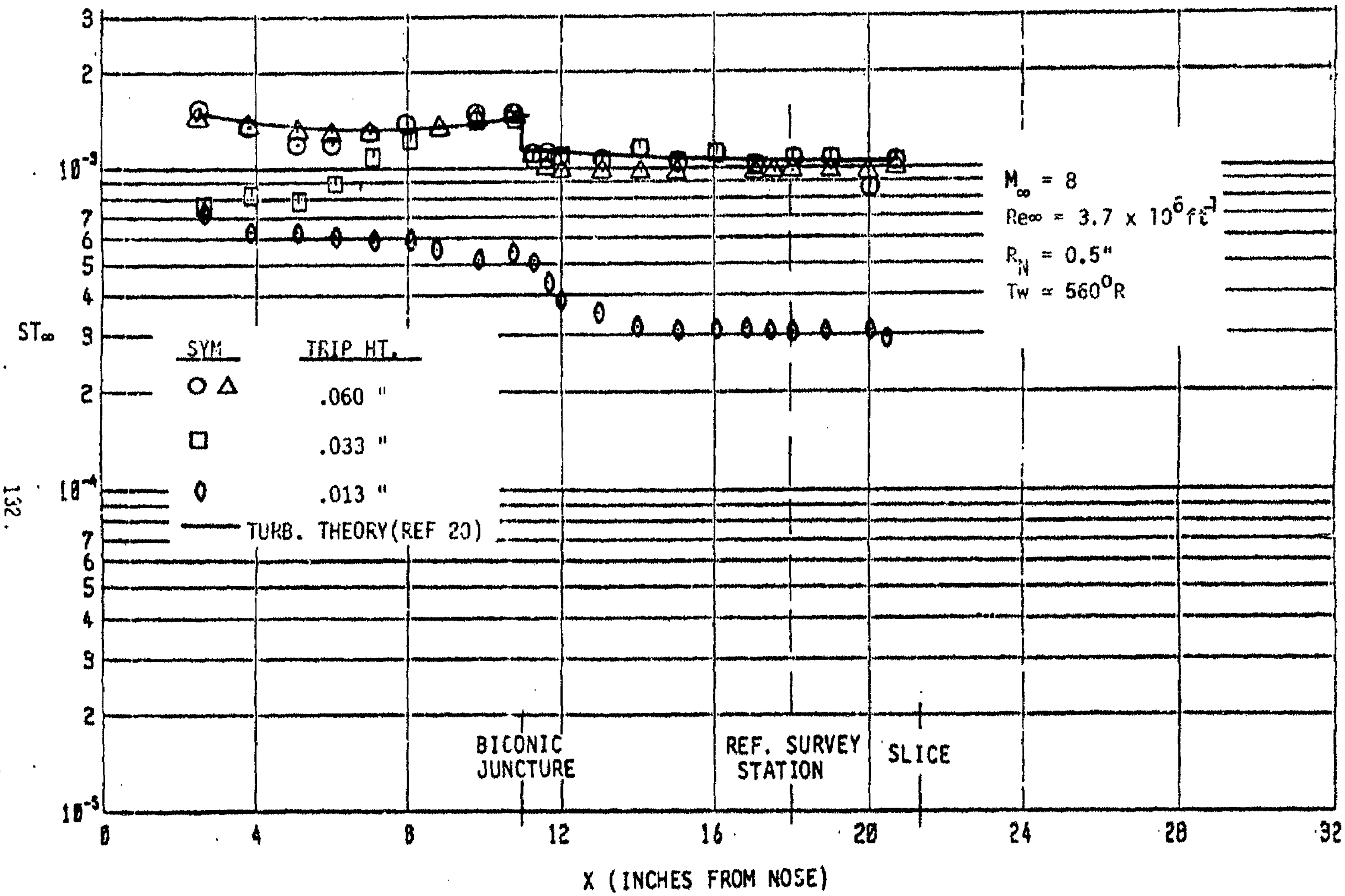


FIGURE 31. BOUNDARY LAYER TRIP EFFECT ON 10.5°/7° BICONE SURFACE HEAT TRANSFER AT $\alpha = 0°$

temperature. Boundary layer trip effectiveness at angle of attack was also investigated. Shown in Figure 32 is the distribution of surface heating on the 0^0 and 180^0 meridional ray at $\alpha = 0$, 4^0, 10^0, and 20^0 for an axial model station 22 inches downstream of the stagnation point (i.e., just upstream of the slice). One will note that at this station the flow on the wind and leeward sides at $\alpha = 20^0$ is turbulent with the 13 mil trip, and is transitional for the smaller values of α.

Complete axial heating distributions obtained at roll angles from 0 to 180^0 at $\alpha = 10^0$ for the 13 mil and 33 mil trip are shown in Figures 33 and 34, respectively. The comparable set obtained at $\alpha = 20^0$ is shown in Figures 35 and 36. These data corroborate the results shown in Figure 32; namely, that the 13 mil trip is ineffective at $\alpha = 10^0$ and is quite effective in promoting turbulent cold wall heating at $\alpha = 20^0$.

From these data, and the associated shock (boundary) layer profile data it was decided that the 33 mil trip would be used for the heat transfer tests, the 60 mil trip for the shock layer survey tests at $\alpha \leq 10^0$ and also the leeside at $\alpha = 20^0$, and the 33 mil trip for the $\alpha = 20^0$ windward side profile test. The concern at $\alpha = 20^0$ (windward) was that with the thinned boundary layer the larger trip would affect the outer inviscid flow; consequently, the smallest trip required to promote turbulence was used.

5.2 Limited Data Trends and Highlights

As indicated earlier, the most significant contribution of the MAT program sponsored tests to the earlier series conducted at AEDC on these cones and bicones was to obtain data on the $10.5^0/7^0$ bicone at $\alpha = 20^0$ and to obtain data with the inclusion of the flap system. In addition to the surface heating, pressure, and shear

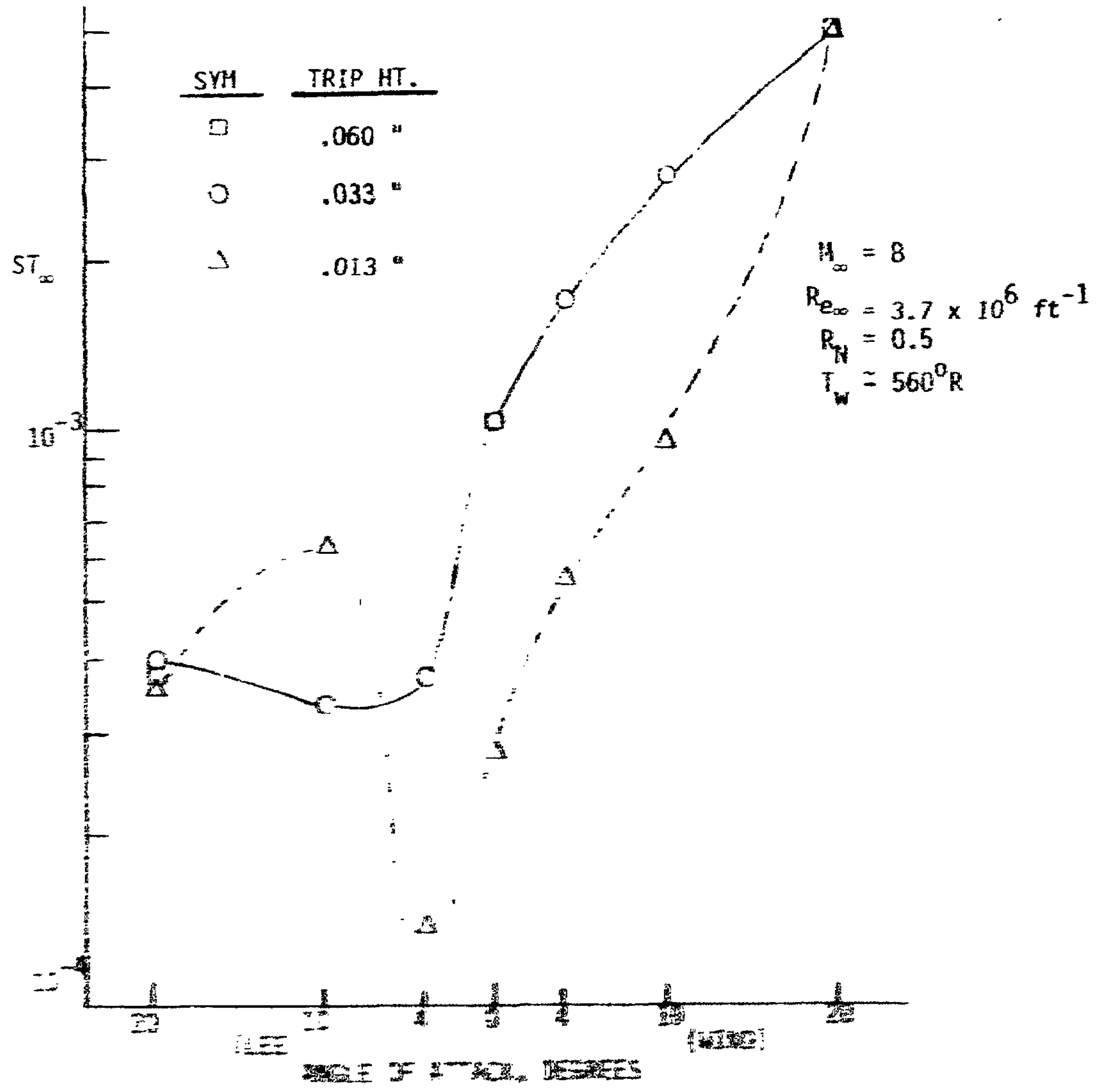


Figure [illegible]. Angle-of-Attack Variation of Heating at x = 22"
for Various Trip Heights

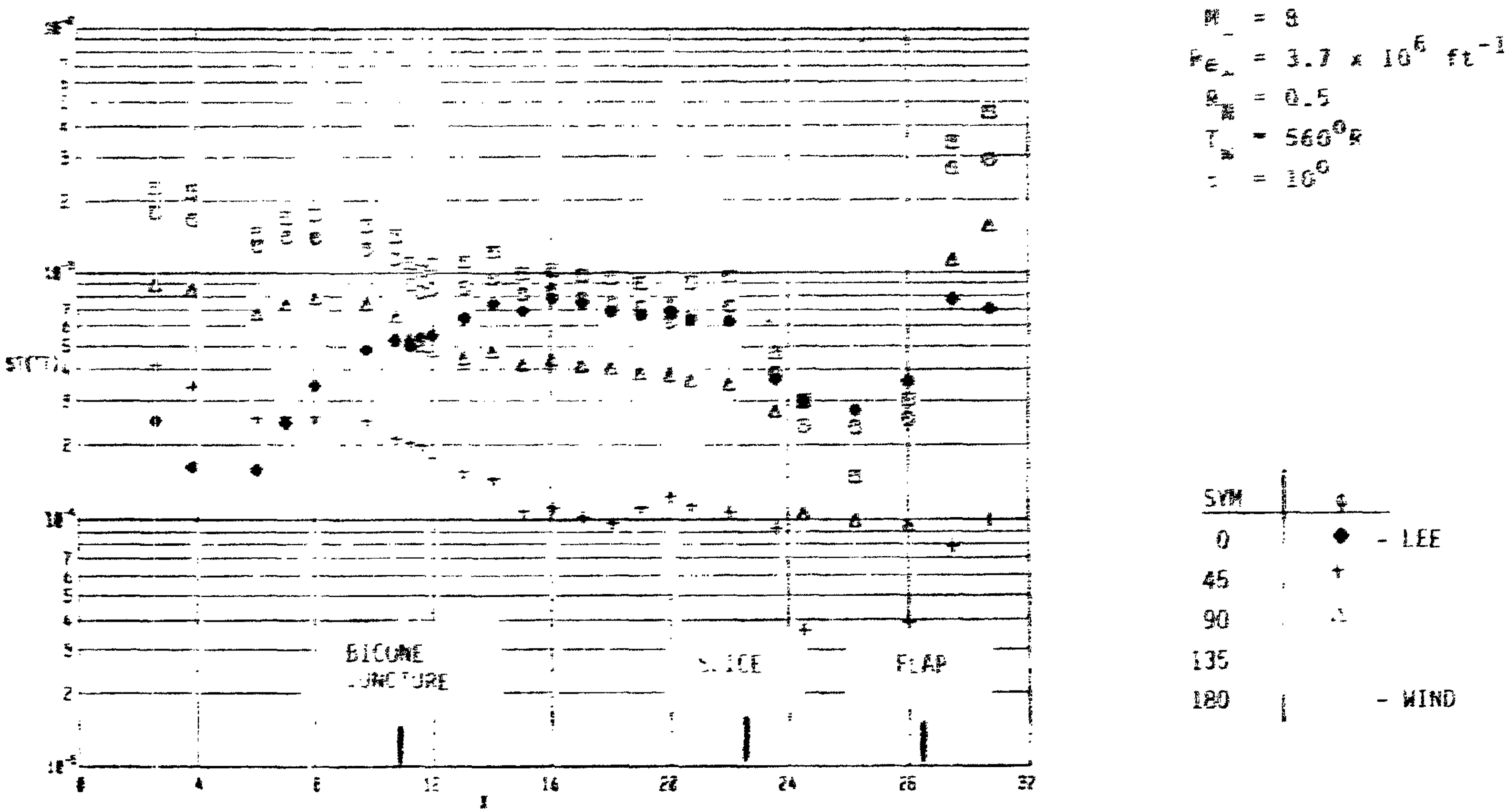


FIGURE 33. AXIAL HEATING DISTRIBUTION FOR SEVERAL MERIDIONAL RAYS
10.5°/7° BICONE WITH 13 MIL TRIP AT $\alpha = 10°$

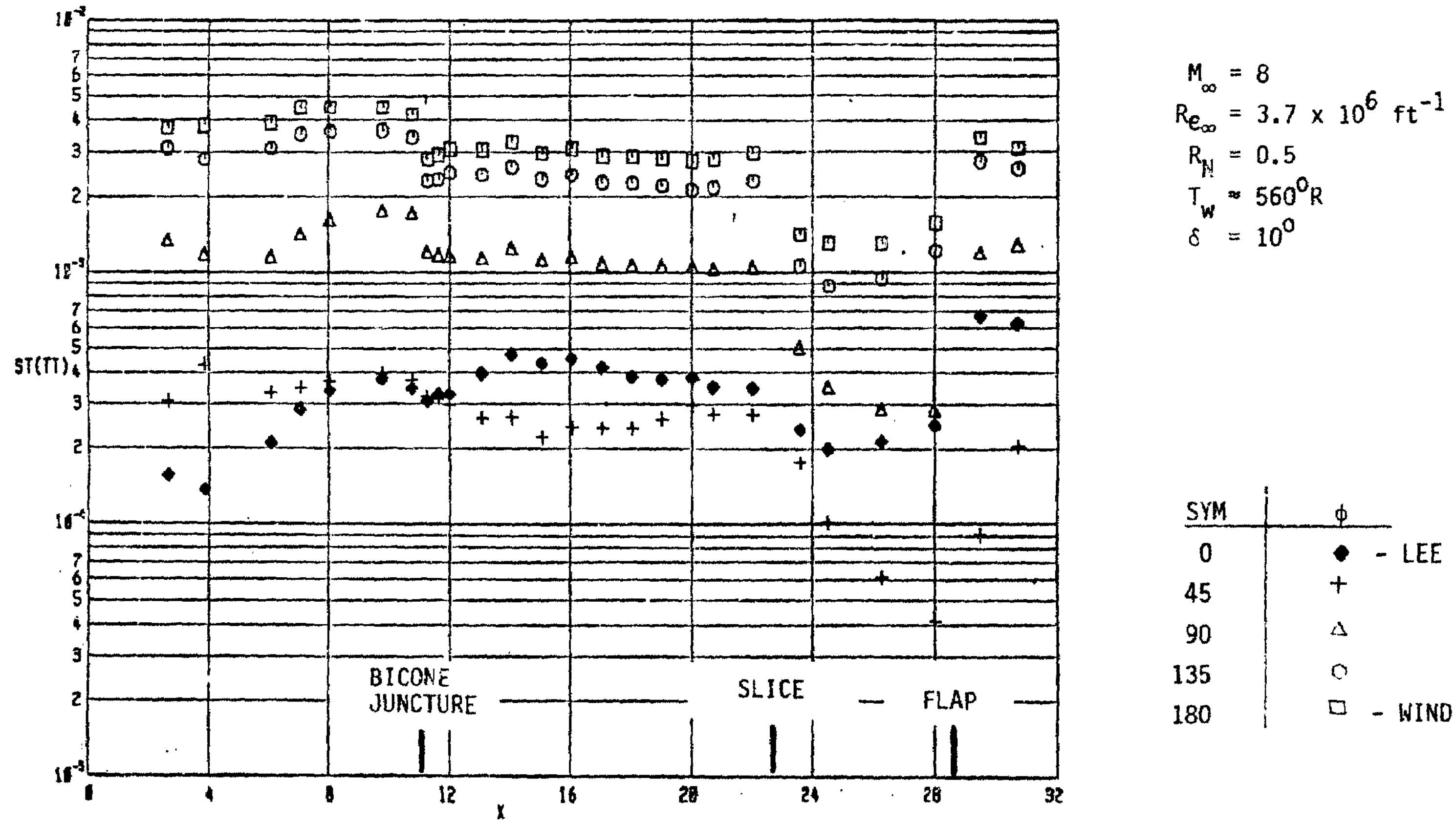


FIGURE 34. AXIAL HEATING DISTRIBUTION FOR SEVERAL MERIDIONAL RAYS
10.5°/7° BICONE WITH 33 MIL TRIP AT α = 10°

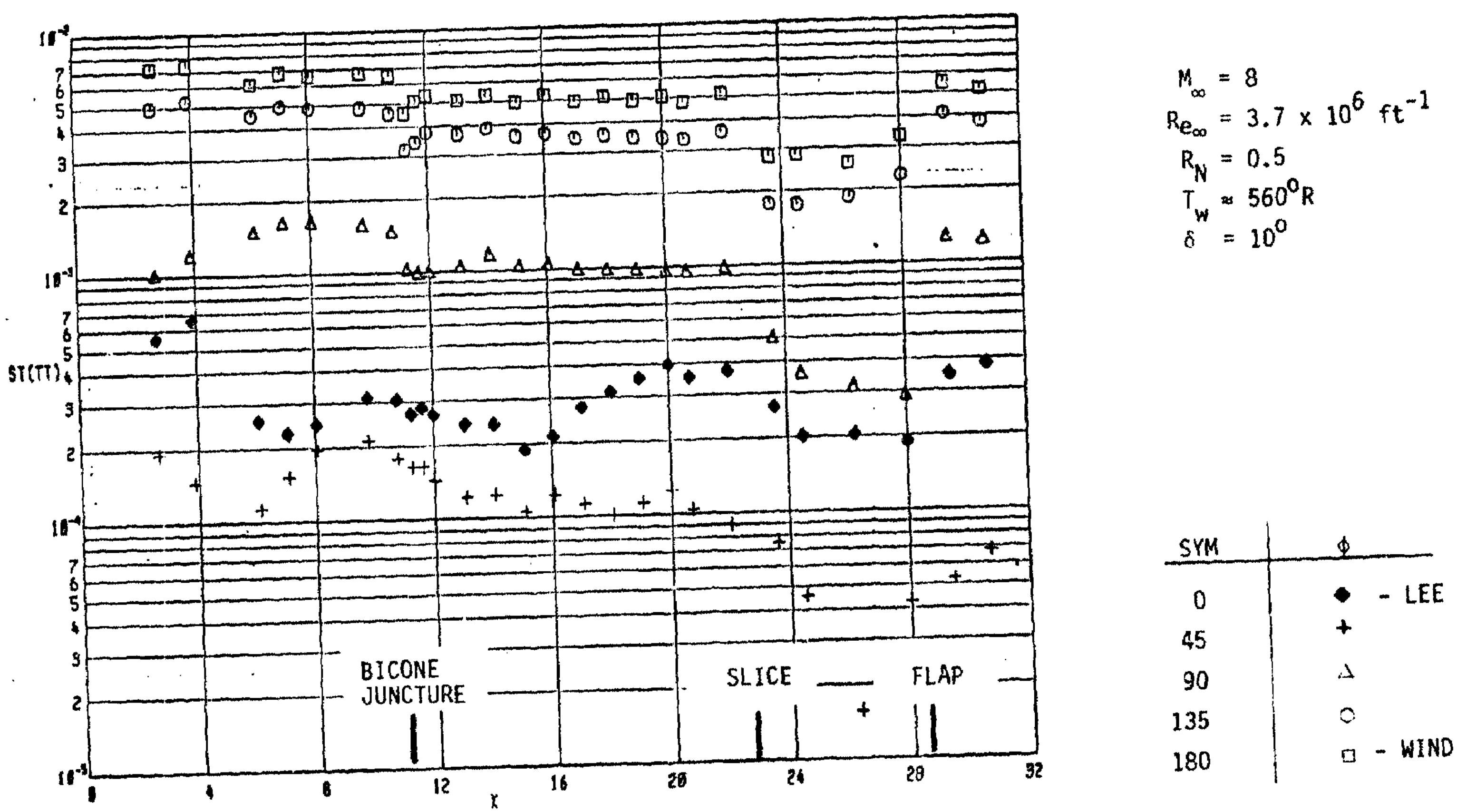


FIGURE 35. AXIAL HEATING DISTRIBUTION FOR SEVERAL MERIDIONAL RAYS
10.5°/7° BICONE WITH 13 MIL TRIP AT $\alpha = 20°$

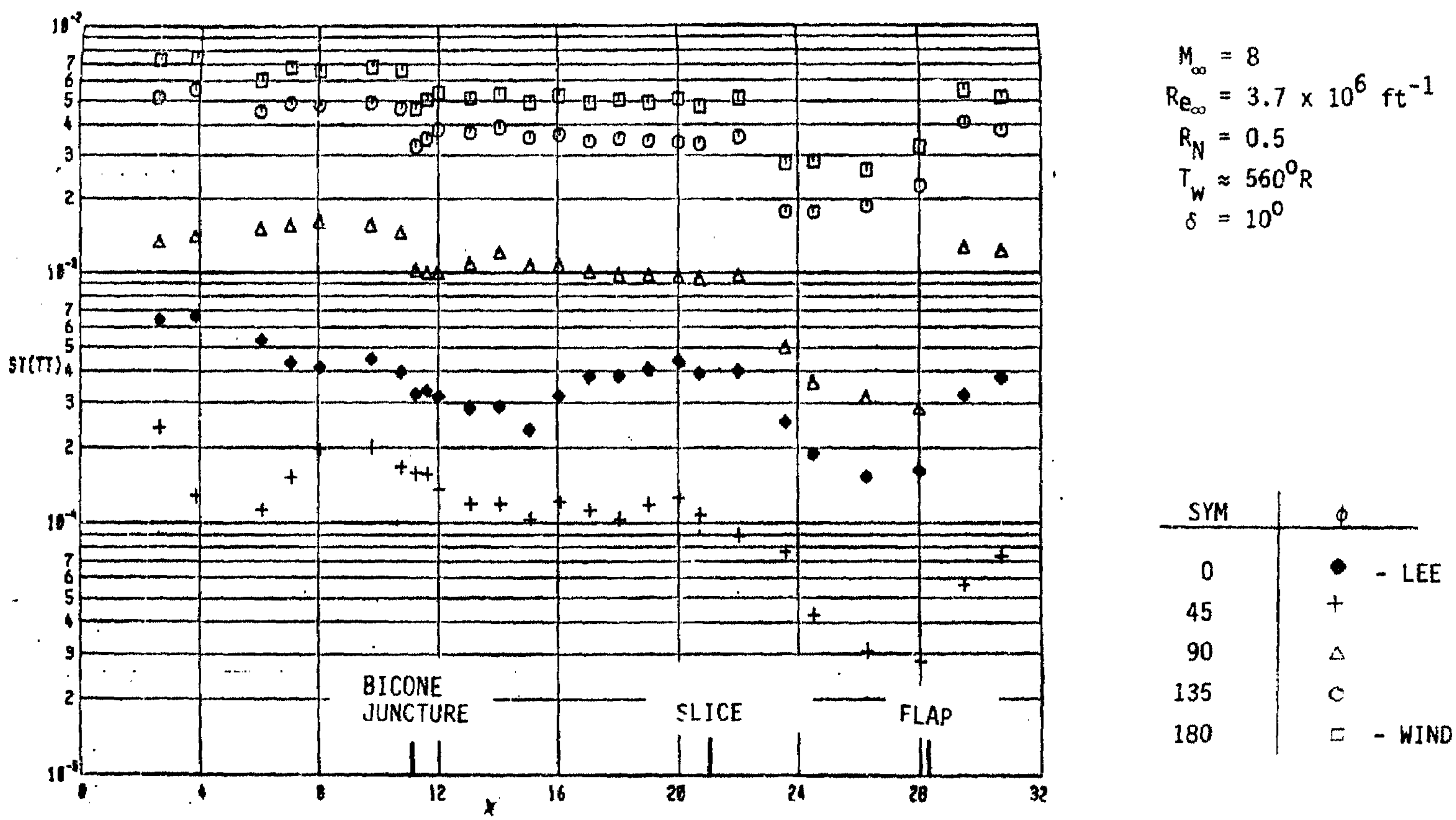


FIGURE 36. AXIAL HEATING DISTRIBUTION FOR SEVERAL MERIDIONAL RAYS
10.5°/7° BICONE WITH 33 MIL TRIP AT $\alpha = 20°$

(Preston tube) measurements, shock layer survey tests were obtained for turbulent boundary layer flow conditions primarily in the slice/flap region. Shown in the schematic of Figure 37 are the nominal locations where shock layer surveys were obtained. The exact locations may be found in the tables presented in Section 3. From this array one can obtain a representative measure of the flow field properties in this slice/flap region along with a reference profile, wind and lee, on the 7^0 cone surface. Shown in Figure 38 is a representative shock layer survey data set on the cone/0^0slice/-7^0slice that would be available for comparison with the detailed computer codes. This particular set is for Mach 8, $\alpha = 0^0$. A representative set of flap shock layer profiles (at station 17, Figure 37) is shown in Figure 39, also for $\alpha = 0^0$. The reader is referred to Section 3.4 for a complete summary listing of the data obtained.

The angle of attack variation of the slice centerline pressure distribution for the blunted $10.5^0/7^0$ bicone is shown in Figure 40. The complementary flap centerline pressure distribition is shown in Figure 41. Also shown in Figure 41 is the pressure distribution on the flap for the sharp ($R_N = 0$) $10.5^0/7^0$ bicone. It is evident from this figure that the flap effectiveness for the blunt configuration is reduced due to vortical (entropy swallowing) flow effects. In addition, the pressure distribution (near $\mathrm{C\!\!\!L}$) for the split flap ($\delta = 20^0/10^0$) is also shown in Figure 41 as the filled symbols. The 20^0 split flap pressure is nominally the same as for the 20^0 continuous flap. However, due to spill-over effects, the pressure on the adjacent 10^0 split flap section is higher than that for the 10^0 continuous flap. Thus the rolling moment produced by the split flap configuration would be smaller than that determined from the continuous 20^0 and 10^0 flap data. It should be noted that since the flap is split on the model centerline the split flap pressures shown are at the offset stations noted in Figure 41. The chord and spanwise pressure distribution for the 10^0 continuous flap at $\alpha = 0$, 4^0, and 10^0, for the

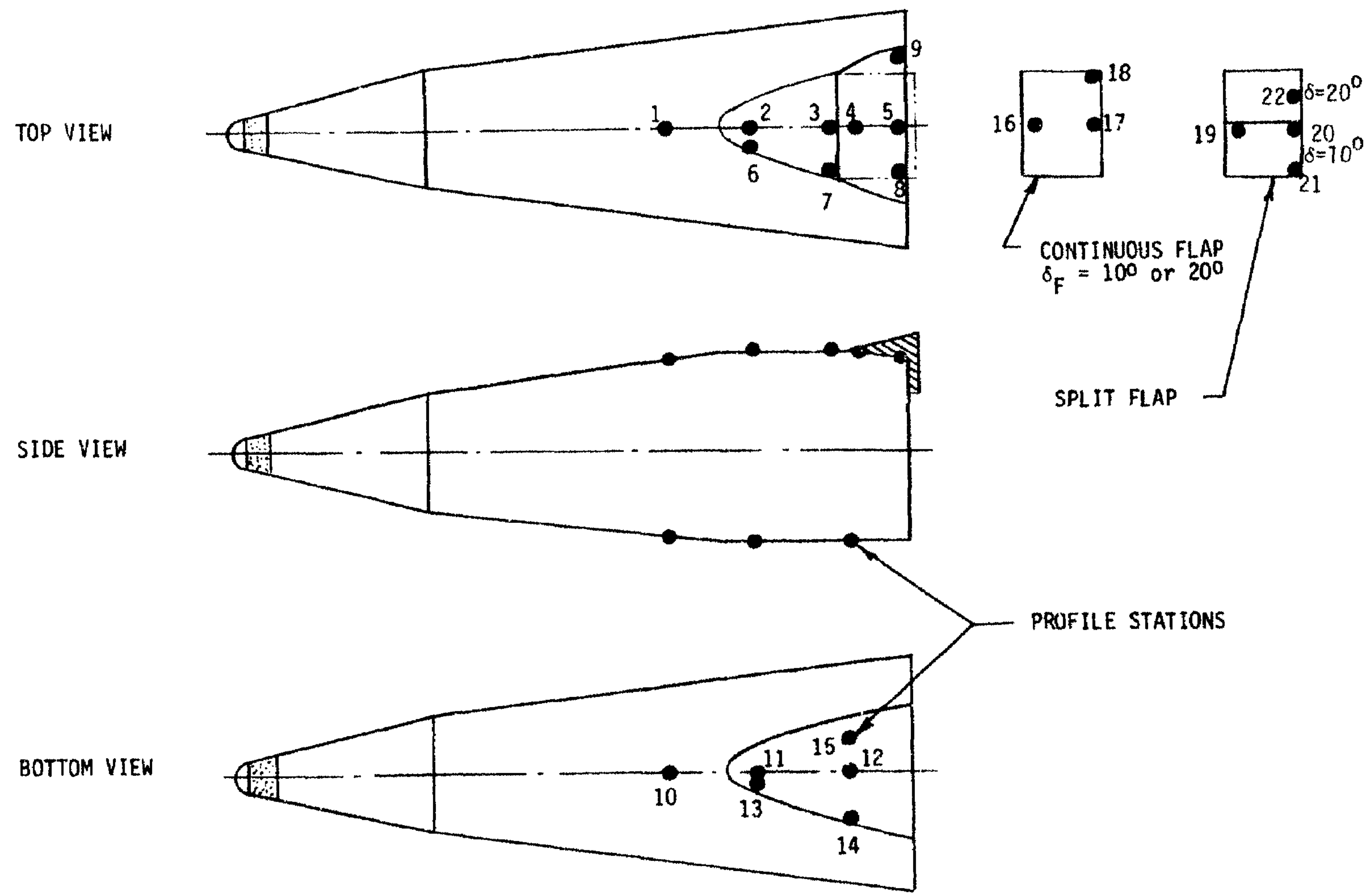


FIGURE 37. SCHEMATIC LOCATION OF THE PROFILE STATIONS ON THE 10.5°/7° BICONE

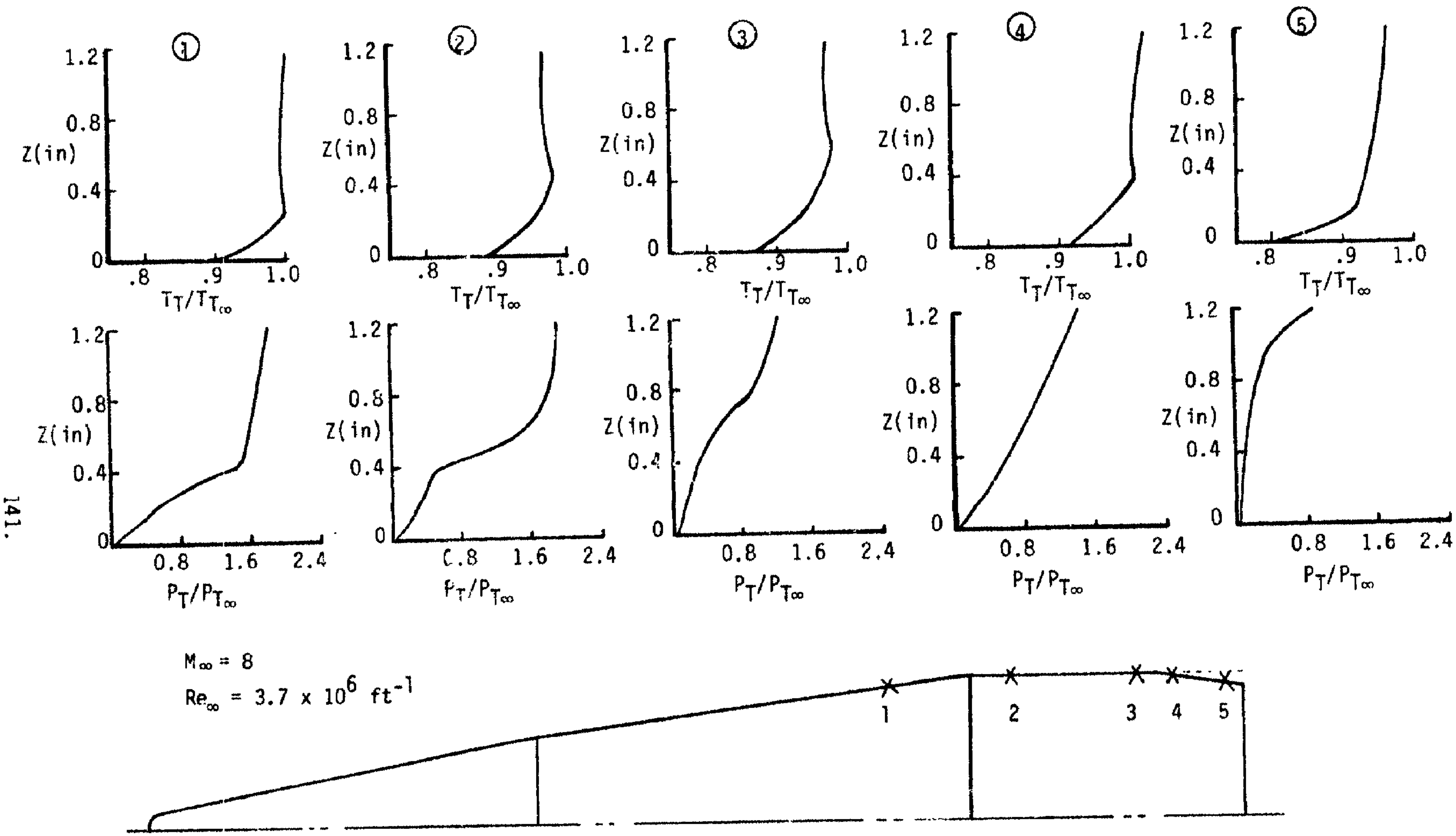


FIGURE 38. REPRESENTATIVE SHOCK LAYER PROFILES ON THE 10.5°/7° BICONE AT $\alpha = 0°$

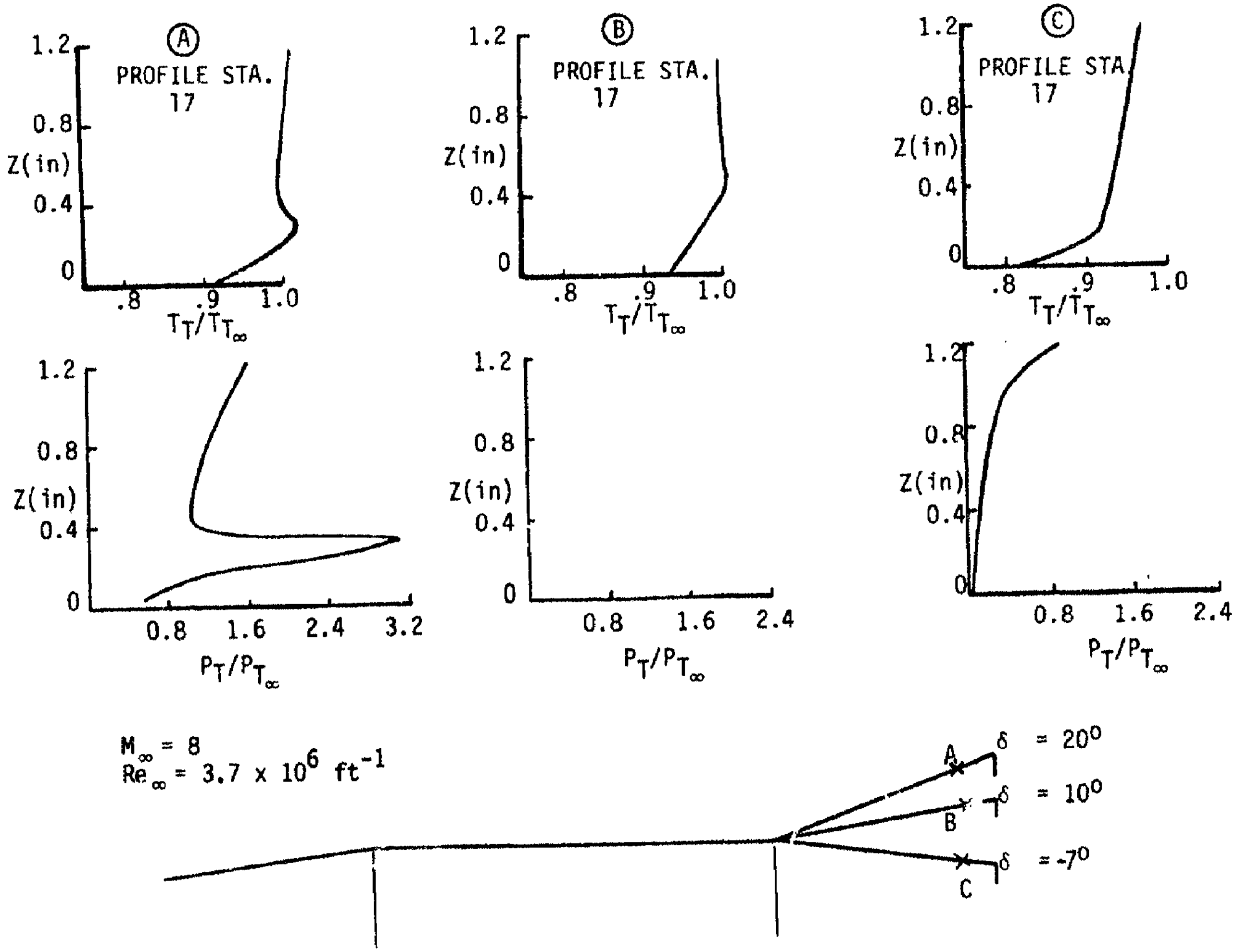


FIGURE 39. REPRESENTATIVE FLAP SHOCK LAYER PROFILES ON THE 10.5°/7° BICONE AT $\alpha = 0°$

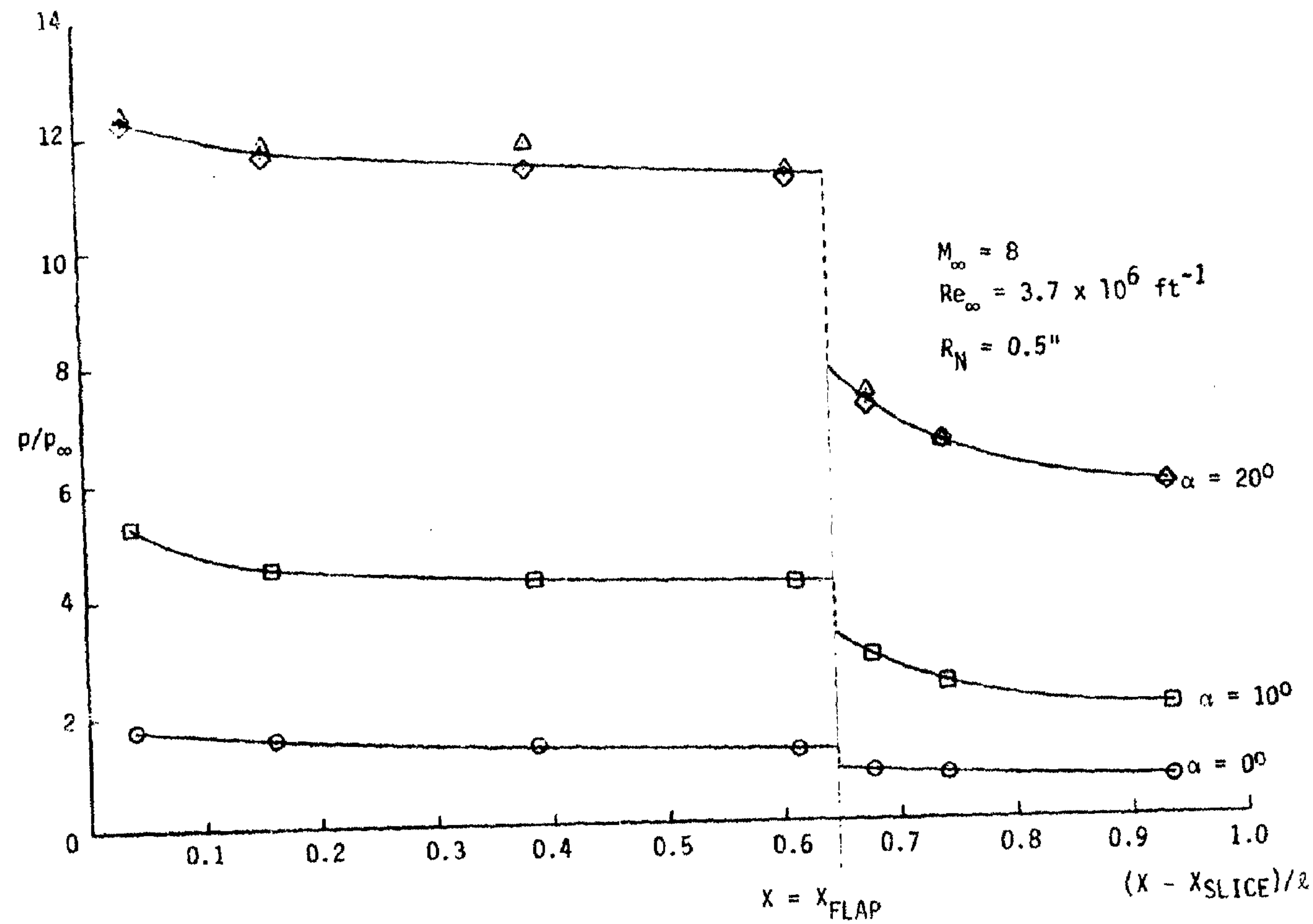


Figure 40. Angle of Attack Variation of the 10.5°/7° Bicone Slice Centerline Pressure Distribution

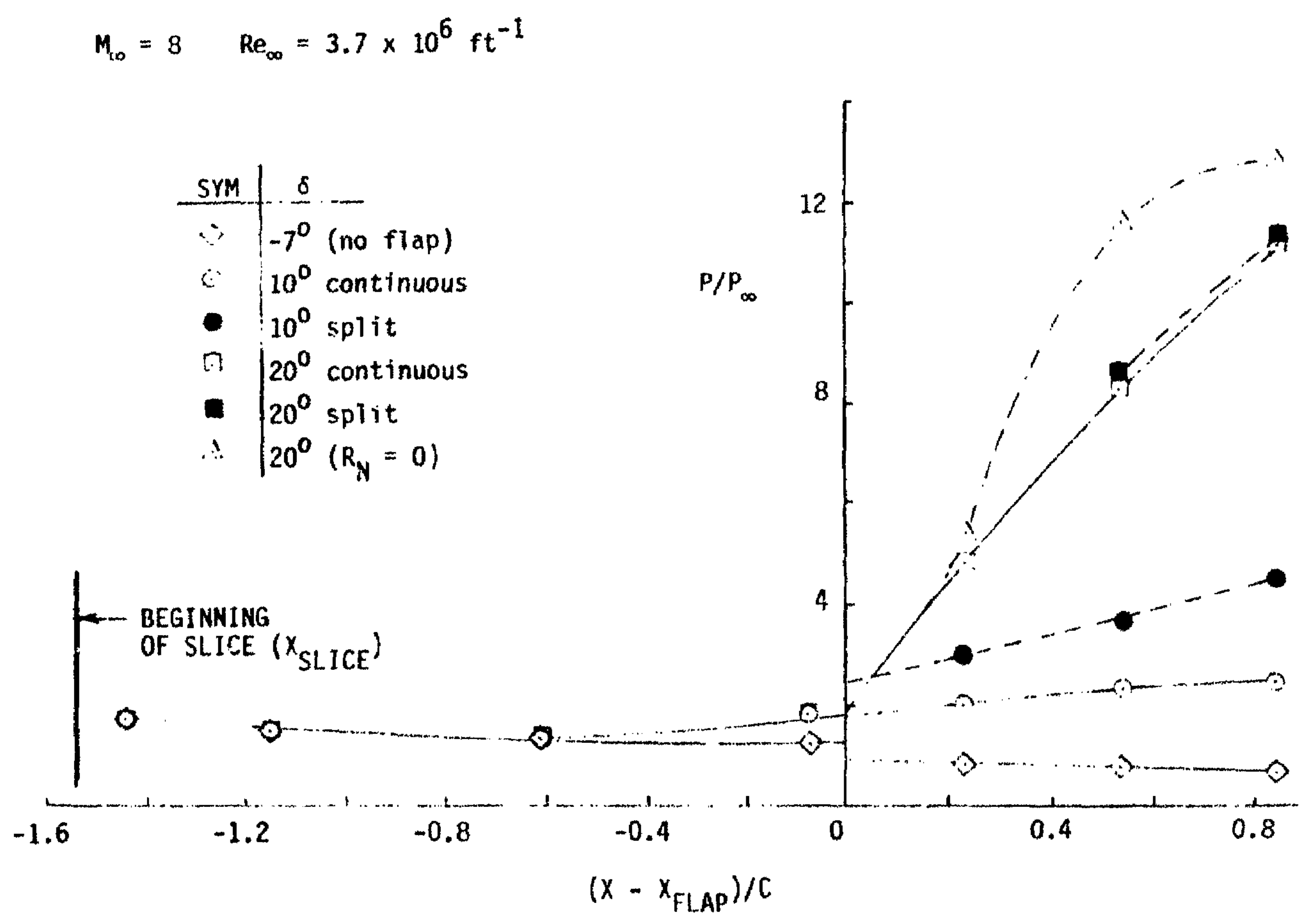


Figure 41. Slice/Flap Centerline Pressure Distribution for the 0.50" Blunted 10.5°/7° Bicone at $\alpha = 0°$

blunted $10.5^{o}/7^{o}$ bicone is shown in Figure 42. It is evident from this figure that at $\alpha = 10^{o}$ one observes a drop-off in pressure near the flap edge which is not present for $\alpha \leq 4^{o}$.

In addition to the pressure distributions recorded, the slice region centerline heating distribution for the blunted $10.5^{o}/7^{o}$ configuration is shown in Figure 43, while Figure 44 depicts the slice/flap heating. Again, also shown in Figure 44 is the heating on the flap for the sharp bicone. One notes that the flap heating, like the pressure, is higher for the sharp bicone due to the absence of vortical flow effects. The variation of the chord and spanwise heating distribution on the 10^{o} flap with angle of attack is shown in Figure 45. The heating is slightly higher near the flap edges $|y|/S \rightarrow 1$ due to the boundary layer thinning.

A sample of the surface shear data, in terms of the skin friction coefficient, $C_F = \tau_w/q_\infty$ as deduced from the Preston tube measurements is shown in Figure 46 for the slice region centerline (vs. α) and for the flap centerline (vs. δ). The variation with α at the frustum and forward slice station is shown in Figure 47. These data should be useful in evaluating the 3D PNS codes ability to handle local three dimensionality associated with the slice and flap.

The limited data presentation shown here does not do justice to the rather extensive data base acquired; rather it serves to demonstrate the type of data acquired. In the following section some few examples of computer code comparisons with select sets of these data will be presented as illustrations of the utility of the data to validate computer code prediction ability.

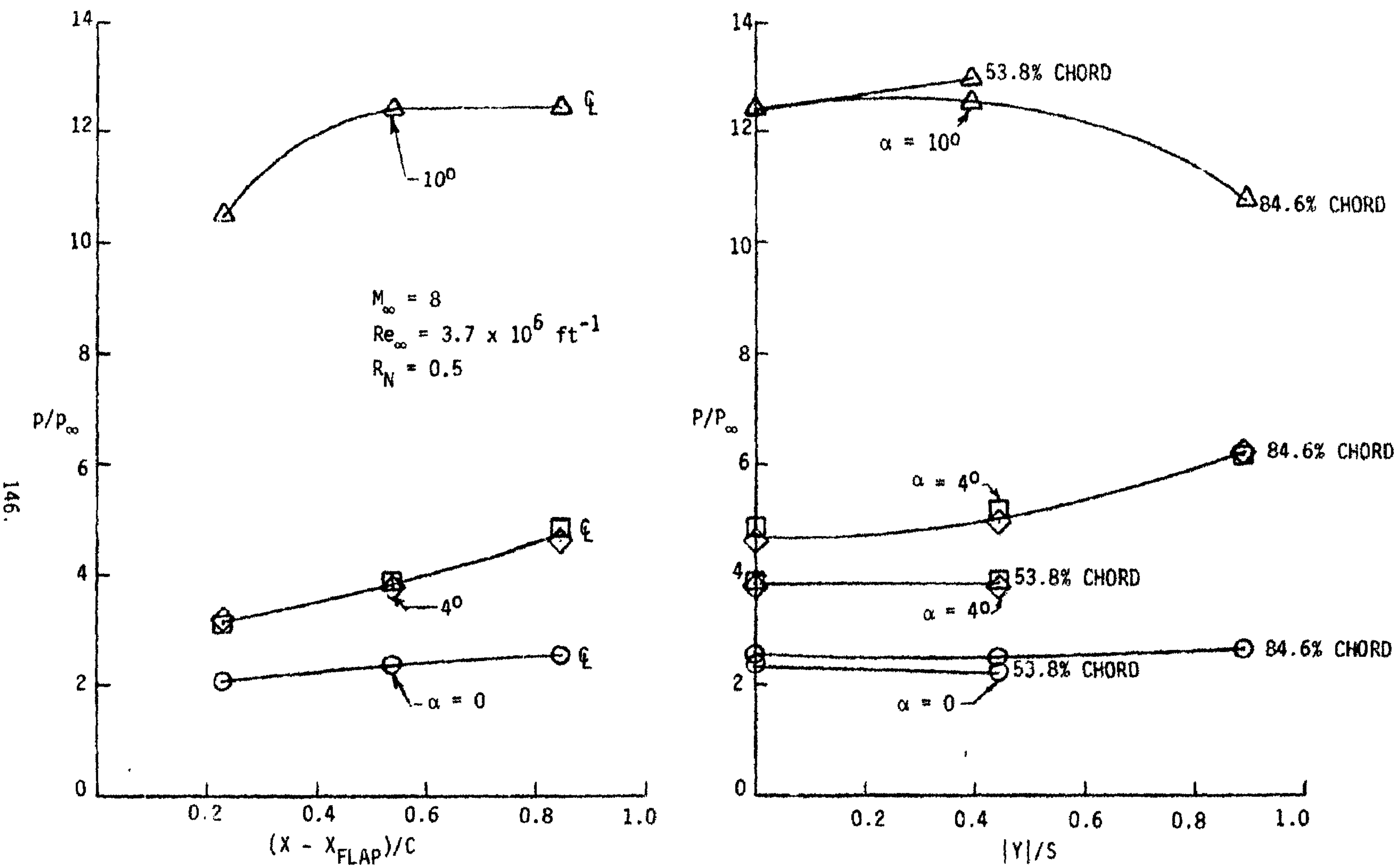


FIGURE 42. CHORD AND SPANWISE DISTRIBUTION OF FLAP PRESSURES FOR $\delta = 10°$

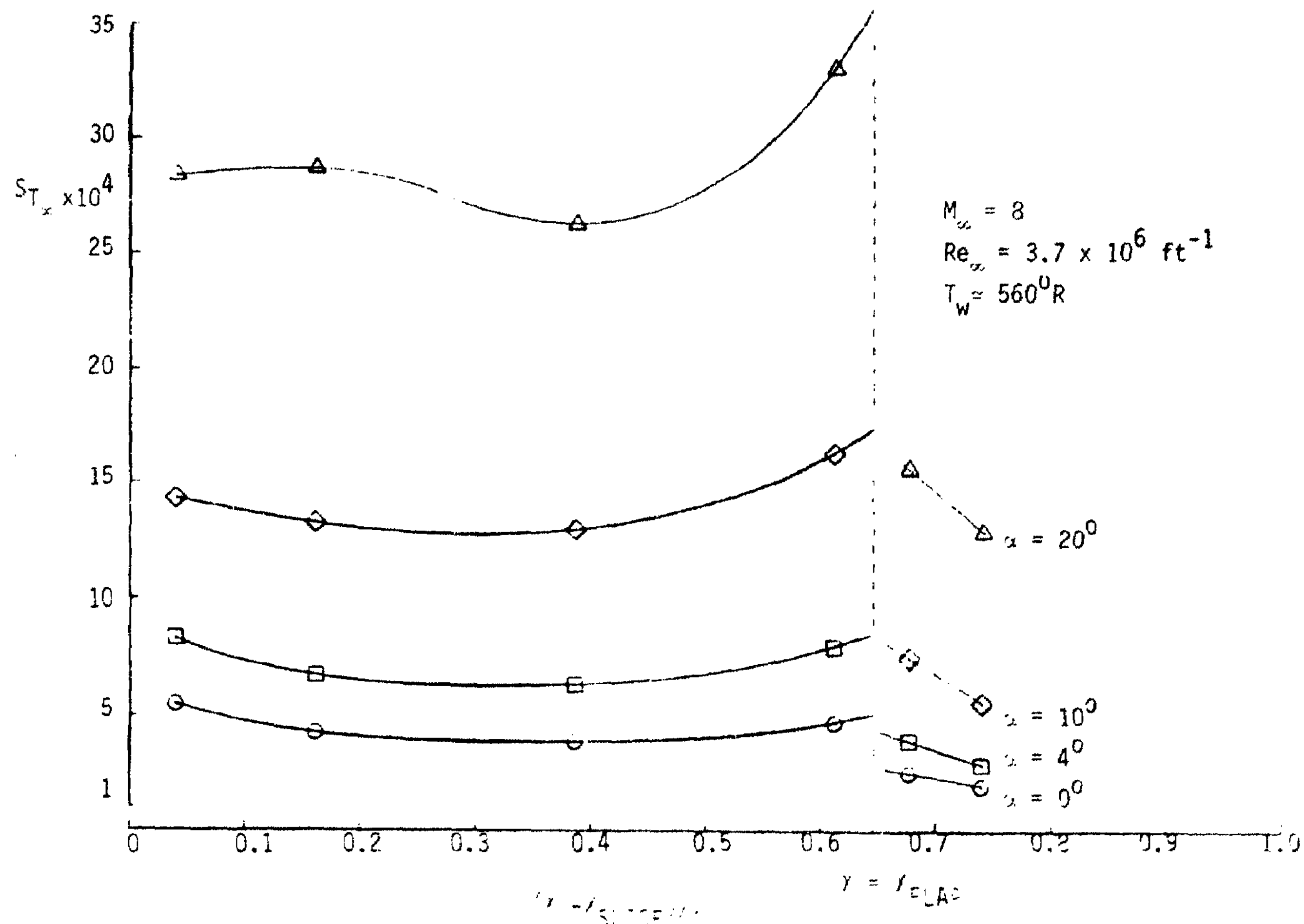


FIGURE 43. ANGLE OF ATTACK VARIATION OF THE 10.5°/7° BLUNTED BICONE CENTERLINE SLICE HEATING DISTRIBUTION

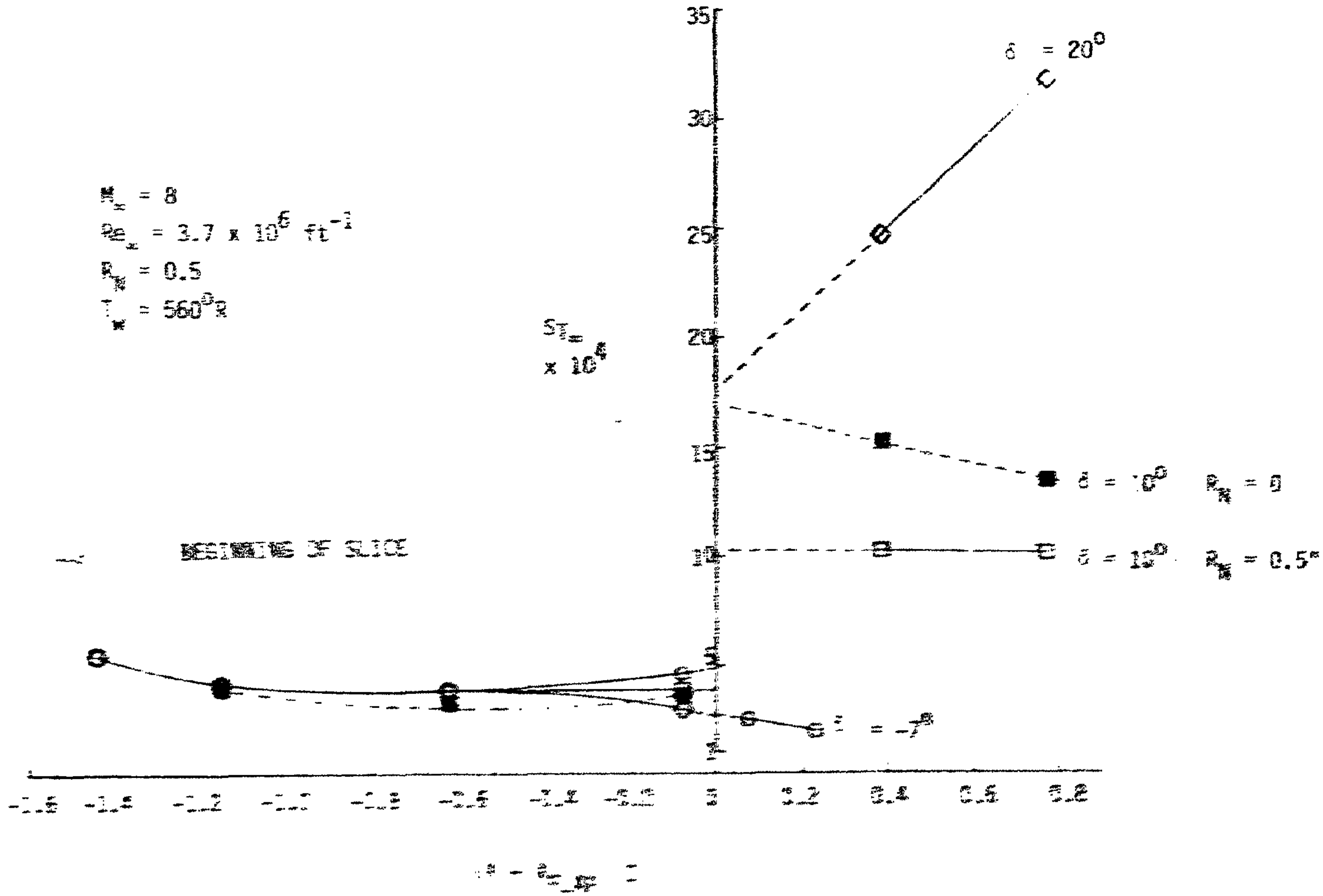


Figure [illegible]. Centerline Heating Distribution on the 10.5°/7° Biconic Slice Flap

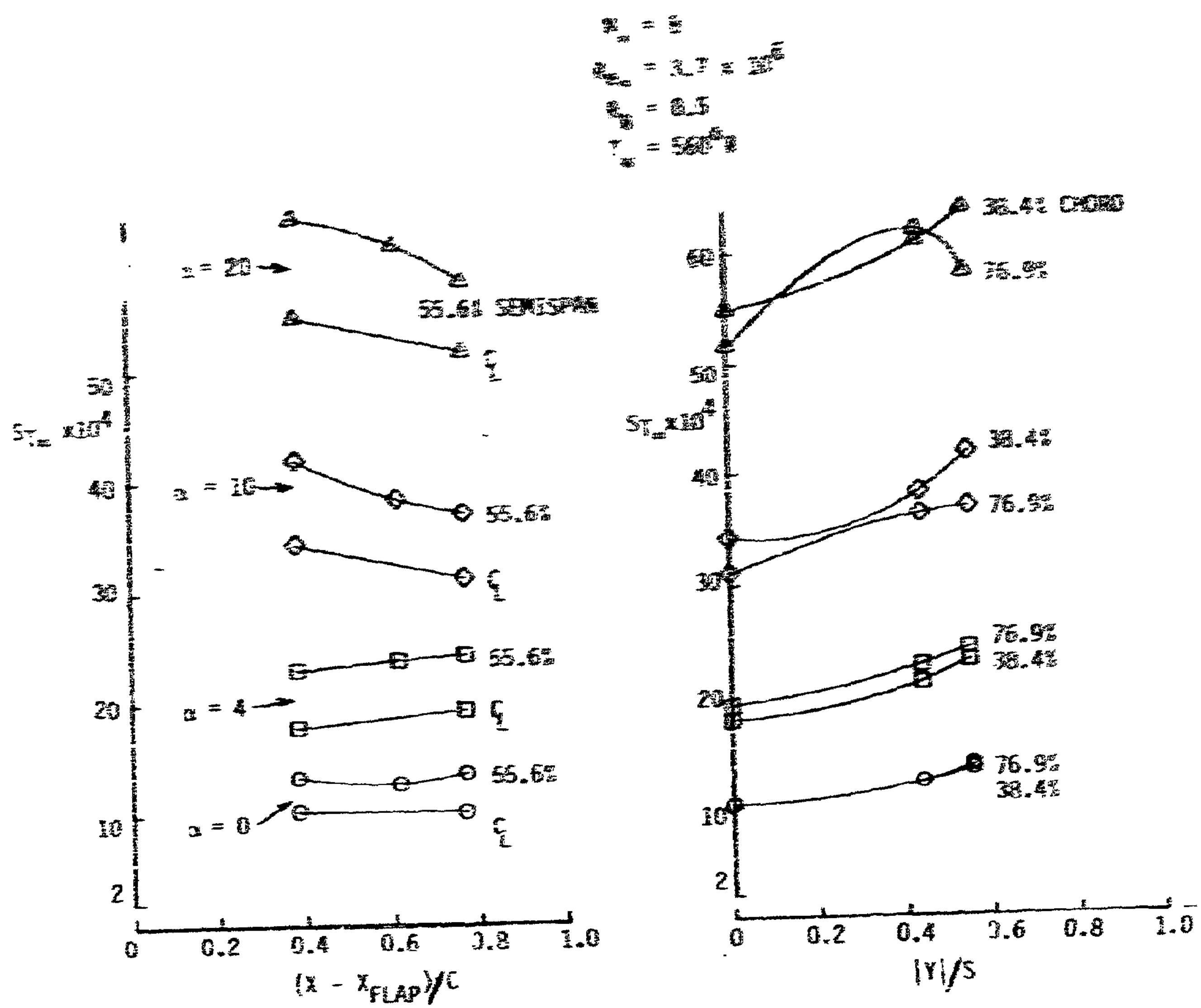


FIGURE 45. CHORD AND SPANWISE DISTRIBUTION OF FLAP HEATING ON THE 10.5°/7° BICONE FOR $\delta = 10°$

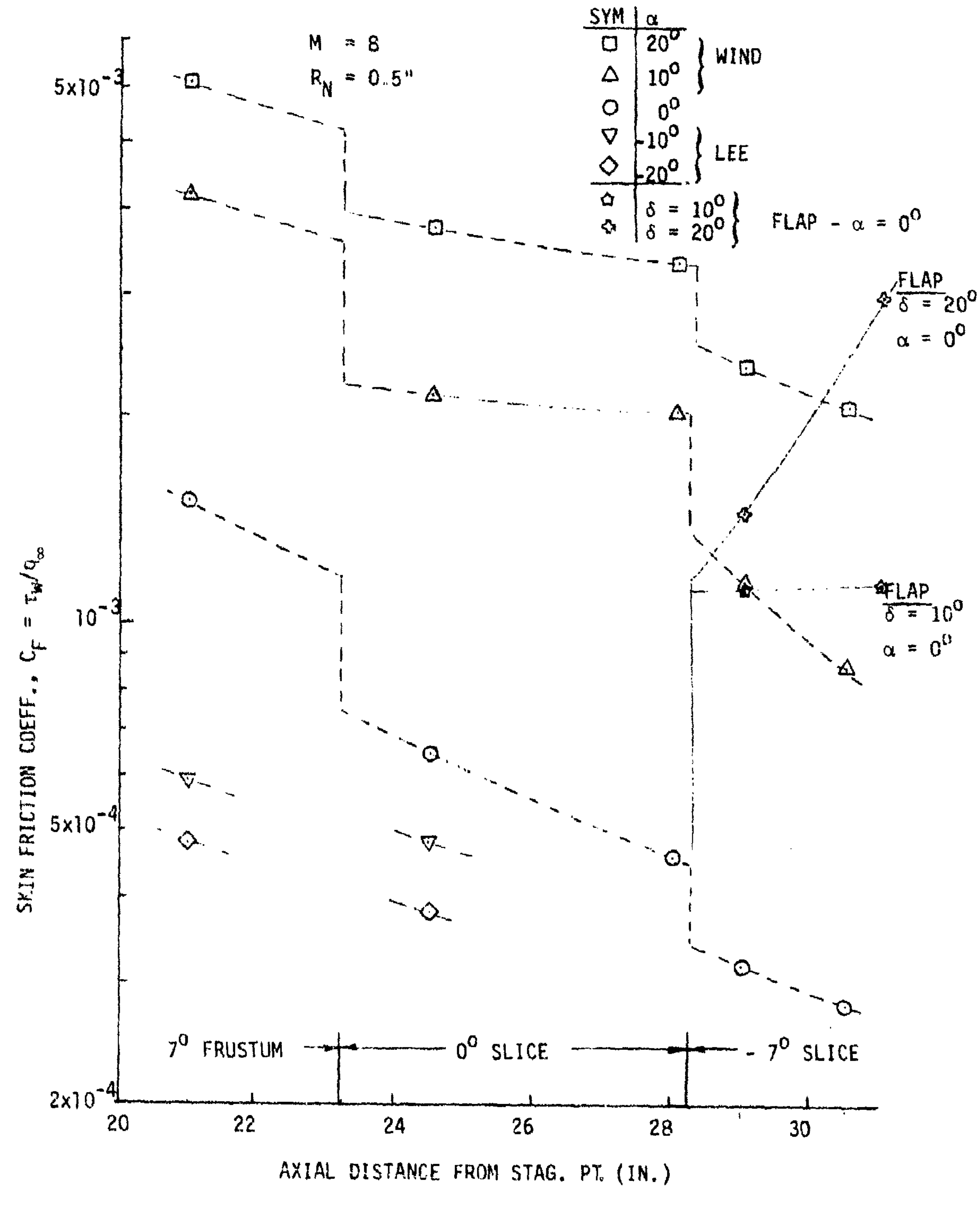


FIGURE 46. SURFACE SHEAR DISTRIBUTION IN THE SLICE REGION OF THE BLUNTED 10.5°/7° BICONE

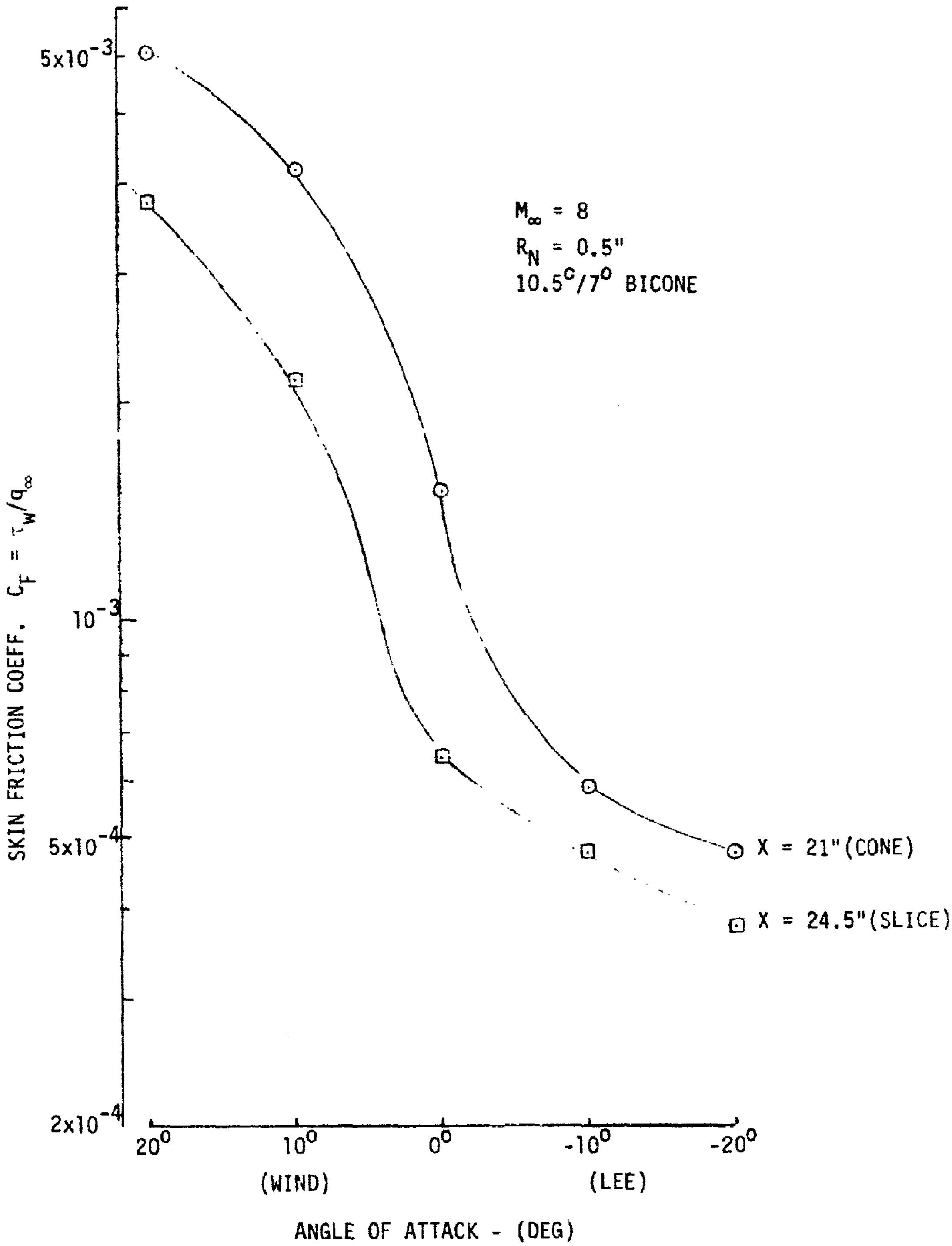


FIGURE 47. SURFACE SHEAR VARIATION WITH ANGLE OF ATTACK CONE AND SLICE REGION

6.0 DATA USAGE FOR TECHNIQUE VALIDATION

As mentioned earlier, one (if not the) primary reason for acquiring this rather large body of data on a current MaRV type configuration is for the validation of complex computer codes. Comparisons of prediction capability with discrete sets of experimental data are generally performed and judgments made relative to code prediction accuracy. Quite often, for example, one is able to adequately predict surface pressure distributions but not static forces and moments. Or, one can predict the laminar heating rate quite well but not the turbulent heating levels. The current set of data provides one consistent base for comparing static loads, surface pressure, laminar and turbulent heating, viscous shear forces, and detailed properties in the shock layer. Sufficient diagnostic data are available to establish the potential cause(s) of an apparent prediction discrepancy if total agreement is not achieved. In this section, several discrete comparisons of code prediction with data will be shown as illustrative examples of the data usage.

6.1 Wall Temperature Considerations

Due to the manner in which the data are obtained in the AEDC Tunnels B and C, the model wall temperature will vary for the different data types. This has been discussed in detail in Section 3. In general, the model wall temperature is initially at ambient room temperature (~540^{o}R). Due to aerodynamic heating the wall temperature varies (increases) with the length of time in the tunnel flow. Thus the Gardon gage heat transfer data, which are obtained in 1-6 seconds after exposure to the flow, will have a wall temperature close to ambient. At the other extreme, the shock layer survey data are obtained after the model has achieved an equilbrium wall temperature; that is, a temperature close to the adiabatic wall value where the convective heating to the model is balanced by the radiative looses to the tunnel

walls. The static force and moment data are generally obtained after several seconds of exposure to tunnel flow - long enough to run through an angle of attack sweep. Thus the model is close to the ambient value. However, one finds that the static forces are not very sensitive to the specific wall temperature value. That is, the normal force and static moment coefficient are primarily dominated by the inviscid pressure field and therefore wall temperature effects are not pertinent. The axial force - specifically the viscous component (which comprises approximately 10% of the total forebody axial force at $\alpha = 0^{0}$ and diminishes with increasing α) is only weakly dependent on the wall temperature. Consequently, the total axial force, to all intents and purposes, is independent of wall temperature.

Model surface pressure measurements are a combination of the inviscid and viscous induced pressure. The latter is weakly dependent on wall temperature. Since the viscous induced increment accounts for less than 5% of the local static pressure, the wall pressure is also independent of wall temperature.

Thus if one wishes to generate computer code predictions and comparisons to a set of data for a prescribed configuration, two runs must be made; one at the cold wall ambient temperature condition ostensibly for heat transfer comparison, and one at the hot wall equilibrium wall temperature condition for comparisons with the profile (including the Preston tube-wall shear) data. Force and moment and wall pressure comparisons can be established from either run.

6.2 Representative Comparisons of Theories with Data

6.2.1 Static Force and Moment

Comparisons of computer code predictions with the data from the current test series have been made with the inviscid codes of

References 21, 22, and 23 and with the PNS code of Reference 24. Shown in Figures 48 and 49 are comparisons of the normal force coefficient, C_N, and pitching moment coefficient, C_m for the blunted 7^0 cone and $14^0/7^0$ bicone predicted with the inviscid codes of References 21-23 and the data from the current test series. One will note that the 3D inviscid code predictions of References 21, 22 are in excellent agreement with the data for α as high as 14^0. It should be noted that although the flow is separated on the leeside for $\alpha \geq 7^0$, the predicted coefficients agree well with the data. It will be shown later that the leeside pressures are poorly predicted with the inviscid code when separation is present (as they should be); however, since the static loads are dominated in hypersonic flow by the windward surface pressures, the good agreement will be shown to be a consequence of good windward surface pressure predictions.

Helliwell, et al[(24)] have generated several comparisons of their version of a parabolized Navier Stokes (PNS) code (called HYTAC) with the data from the current tests. Shown in Figure 50 are comparisons of HYTAC with $14^0/7^0$ sliced bicone (without a flap) laminar flow data taken at Mach 10 (see Section 3.3). One notes that up to $\alpha = 10^0$ agreement is excellent. To generate these comparisons one need only set up the geometry, free stream conditions and vary α.

6.2.2 Surface Static Pressure

Comparisons of data from the current test series were made with the PNS codes of References 24 and 25 and with the inviscid code of References 21 & 22. Shown in Figures 51 and 52 are comparisons made with the PNS codes of References 24 and 25, with the surface pressure data obtained at the Mach 8 condition on the $10.5^0/7^0$ bicone with a double windward slice and single leeward slice at $\alpha = 0^0$ and 10^0, respectively. At $\alpha = 0^0$, the agreement between theory and data on the conic surfaces is quite good; however, code improvements are needed in the slice region to affect better agreement. It is in this context

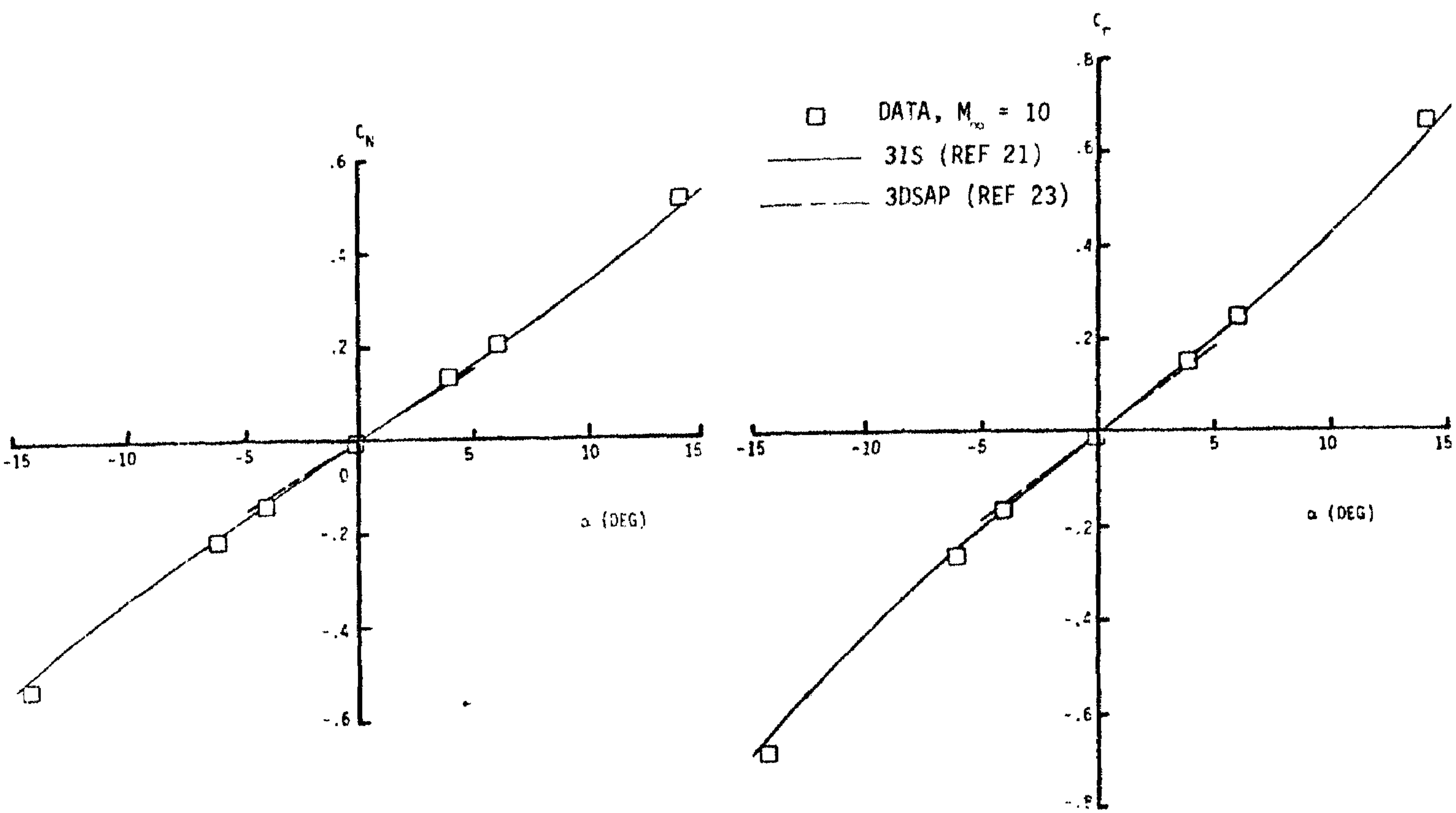


FIGURE 48. FORCE AND MOMENT COEFFICIENTS FOR THE 0.5"R BLUNTED 7°CONE

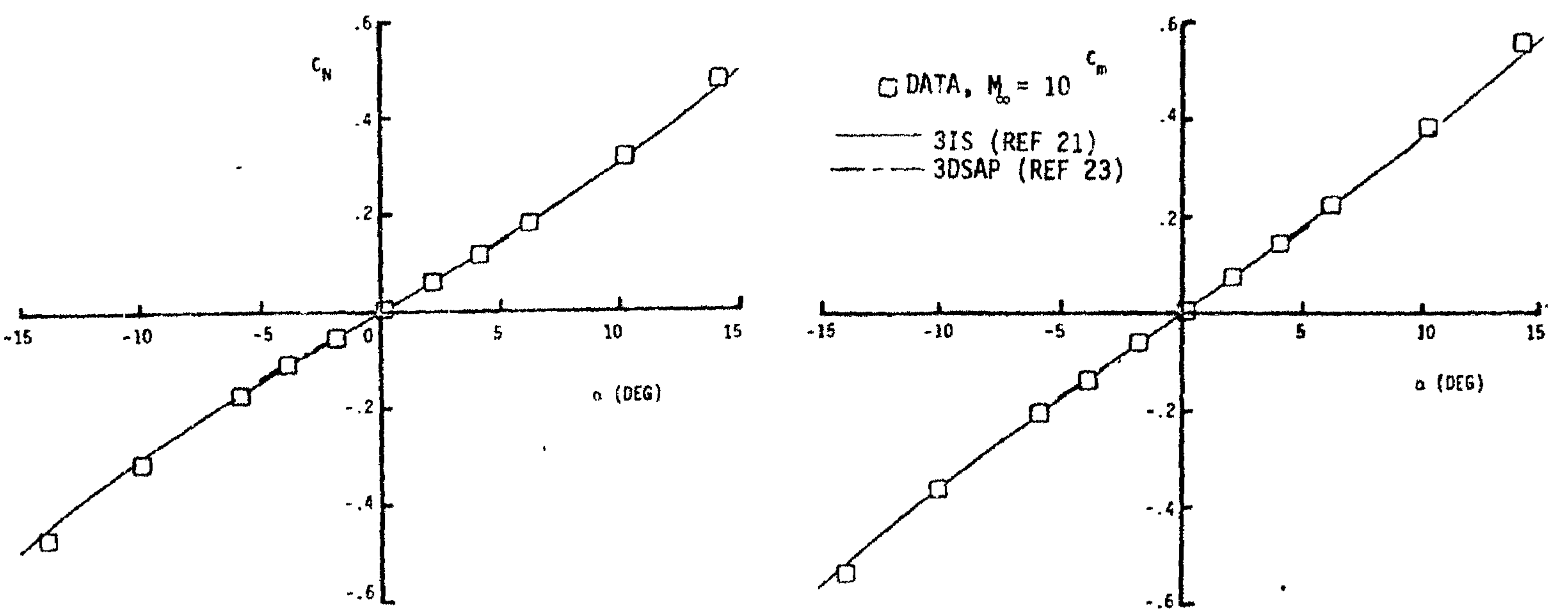


FIGURE 49. FORCE AND MOMENT COEFFICIENTS FOR THE 0.5"R BLUNTED 14°/7° BICONE

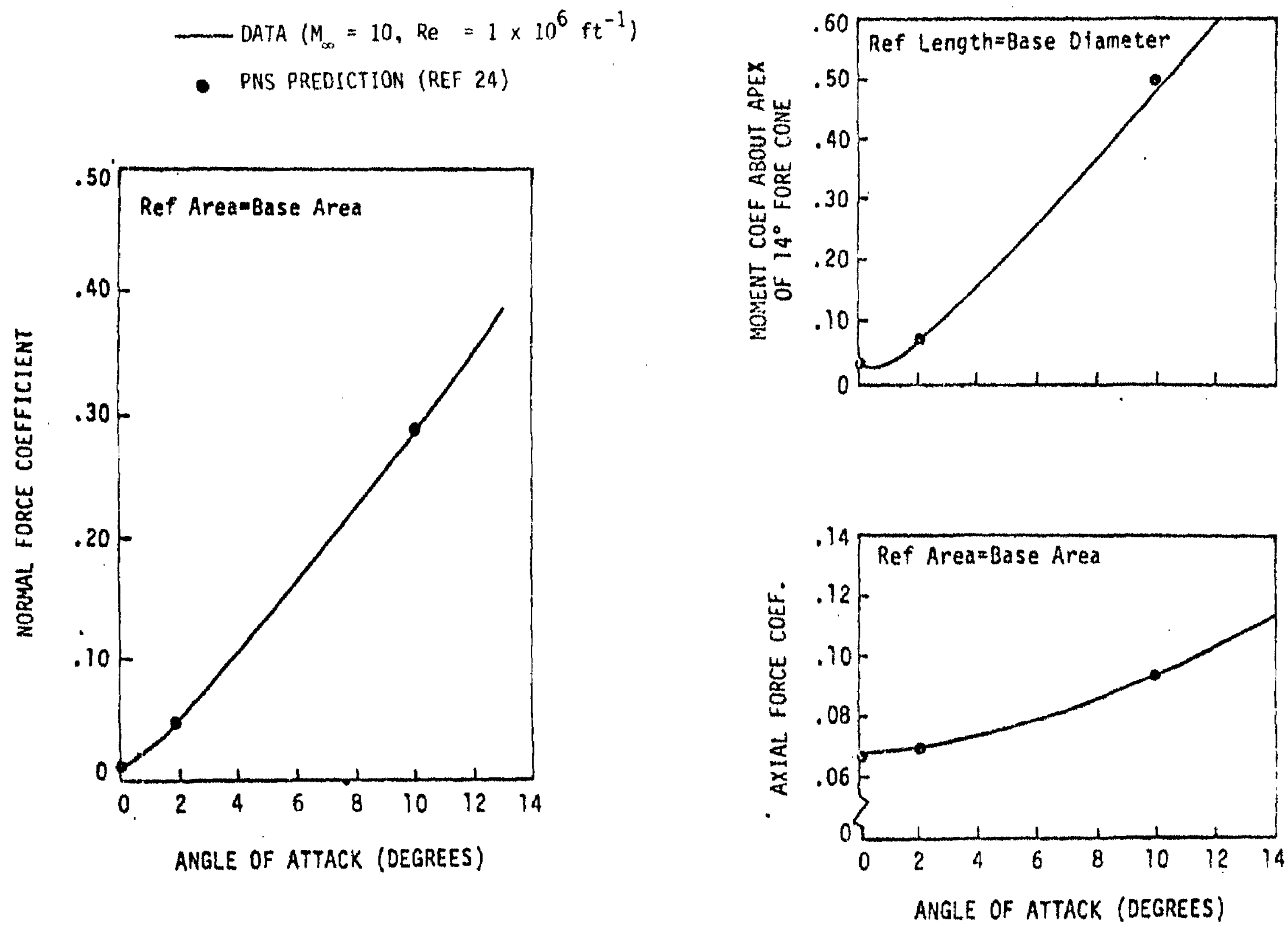


FIGURE 50. FORCE AND MOMENT COEFFICIENT COMPARISONS FOR THE BLUNTED 14°/7° BICONE WITH WINDWARD CUT

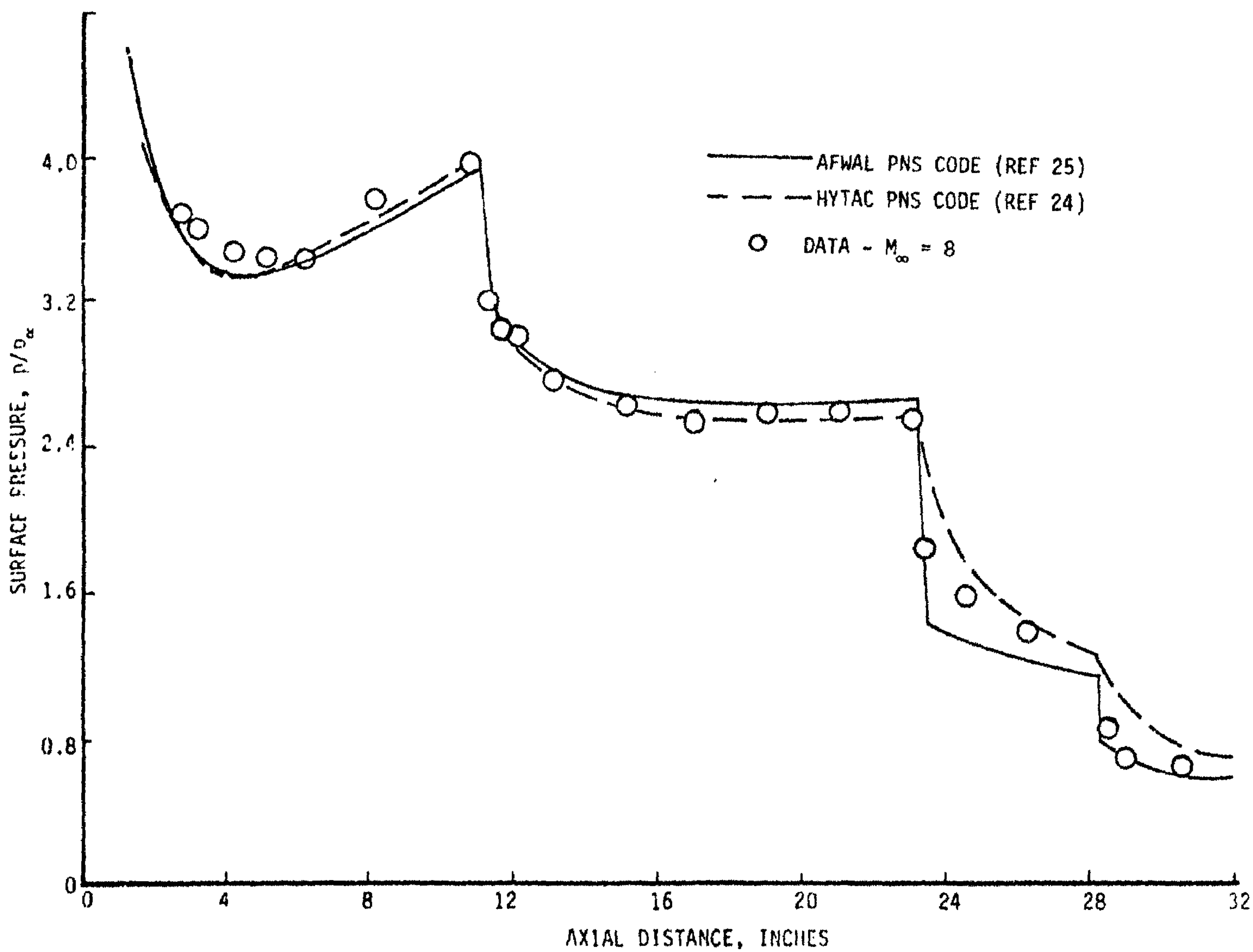


Figure 51. Longitudinal Pressure Distribution on the Blunted 10.5°/7° Bicone at α = 0°

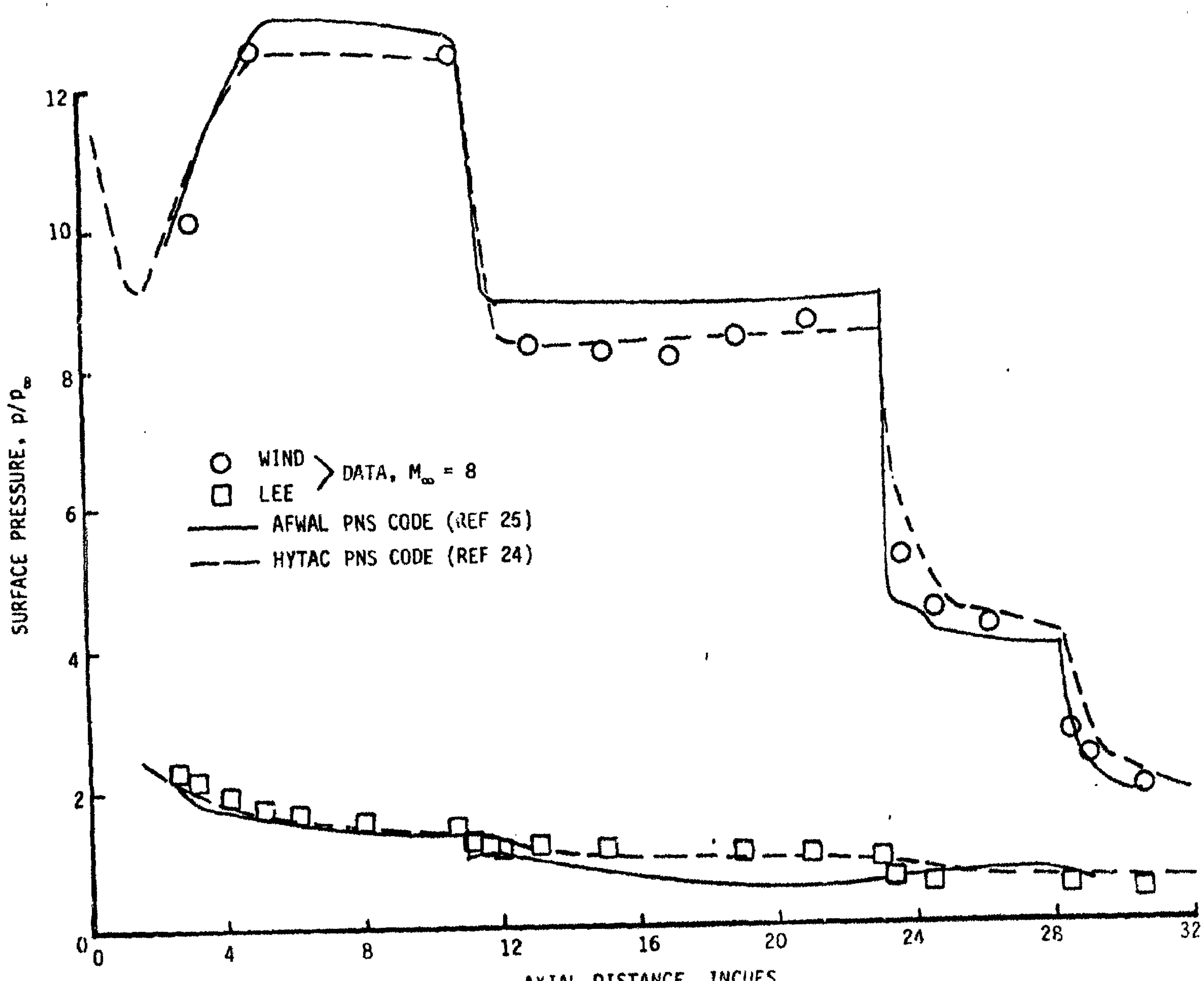


FIGURE 52. LONGITUDINAL PRESSURE DISTRIBUTION ON THE BLUNTED 10.5°/7° BICONE AT $\alpha = 10°$

that the complementary profile data are useful in providing another diagnostic for establishing the time cause of the numerical difficulty. At $\alpha = 10^0$ (Figure 52), one notes that the HYTAC code agrees well with the data on the conic surface where as the AFWAL code tends to overpredict the aft cone pressure on the windward side and underpredict on the leeward side. Fair agreement in the slice region is evident. Subsequent to these comparisons being made, improvements to the AFWAL code were made (in terms step size determination and numerical damping) and although not shown here, better agreement was achieved at $\alpha = 10^0$.

In the test series defined in Section 3.4, data were obtained on the $10.5^0/7^0$ bicone with the flap system installed. Data were taken at Mach 8 (turbulent flow) at $\alpha = 0^0$ with flap deflection angle, $\delta = -7^0$ (no flap) and for $\delta = 10^0$ and 20^0, and at $\alpha = 10^0$ for $\delta = -7^0$ and $\delta = 10^0$. Shown in Figures 53 and 54 are comparisons of the AFWAL PNS code prediction (Reference 25) with the measured surface pressure data. At the time these predictions were made, difficulties were being encountered with the PNS code predictions associated with the marching step size. Shown in Figure 53 are predictions for two values of step size, DX. One notes that although better agreement is shown for DX = 0.10 than 0.05, numerical instabilities are encountered for $\delta = 20^0$ case. Again the associated flow field survey data (shown in Section 6.2.4) are extremely useful in resolving this difficulty. At $\alpha = 10^0$, the numerical solutions did not have this sensitivity and one notes that relatively good agreement was achieved.

In addition to the surface pressure comparisons made with the PNS codes, data comparisons were also made with the 3D inviscid code of References 21, 22. Shown in Figures 55 and 56 are axial and peripheral surface pressure distribution comparisons of the inviscid code prediction with the Mach 8 data for the blunted (0.5" R_N) $10.5^0/7^0$ bicone at $\alpha = 10^0$. The agreement of theory with data is excellent on the windward surface, however, agreement for $\phi > 90^0$ is rather poor (as one would expect from an inviscid technique). Since the pressure on the windward surface is more than an order of magnitude greater

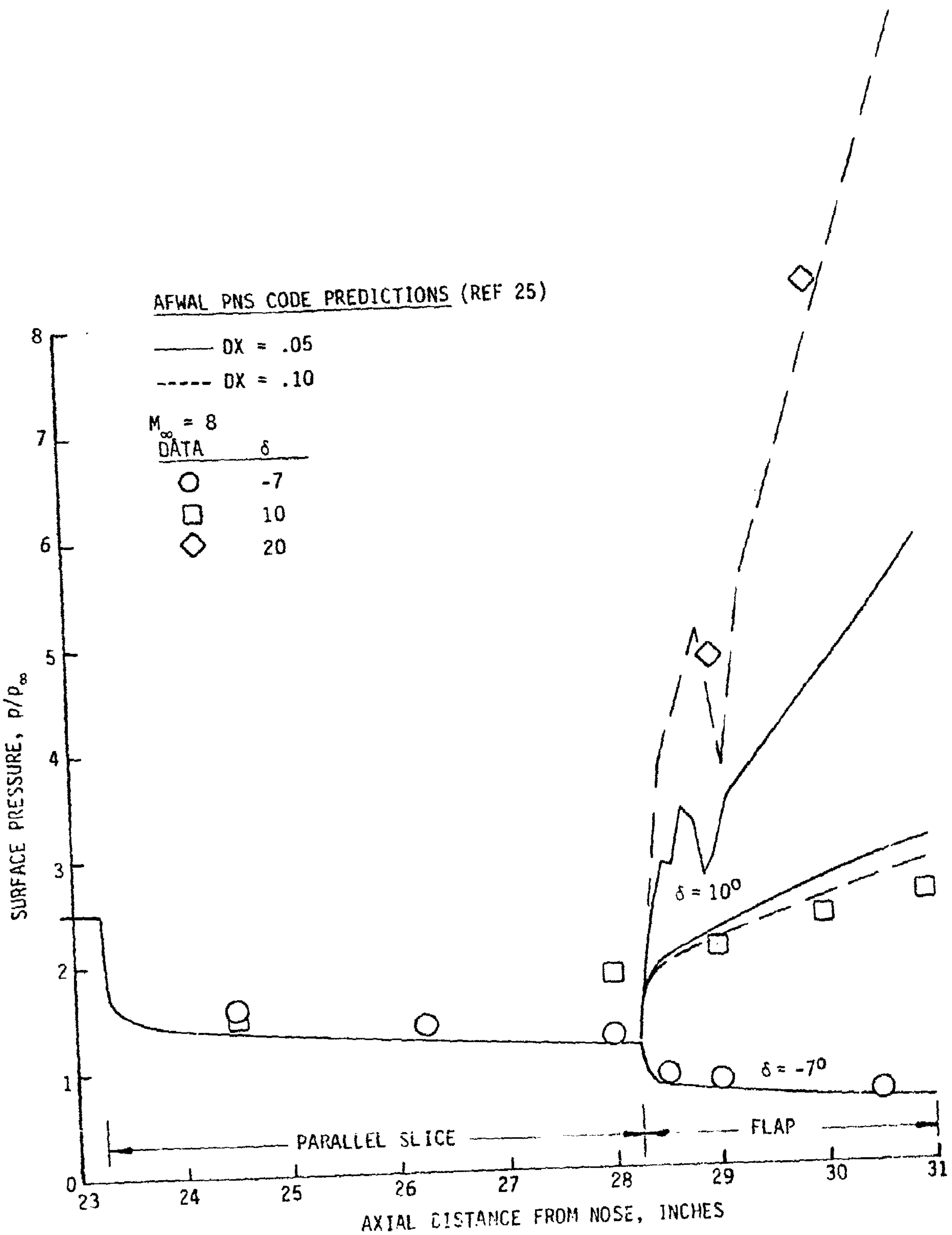


FIGURE 53. SURFACE PRESSURE DISTRIBUTION IN THE 10.5°/7° BLUNTED BICONE CONTROL REGION - α = 0°

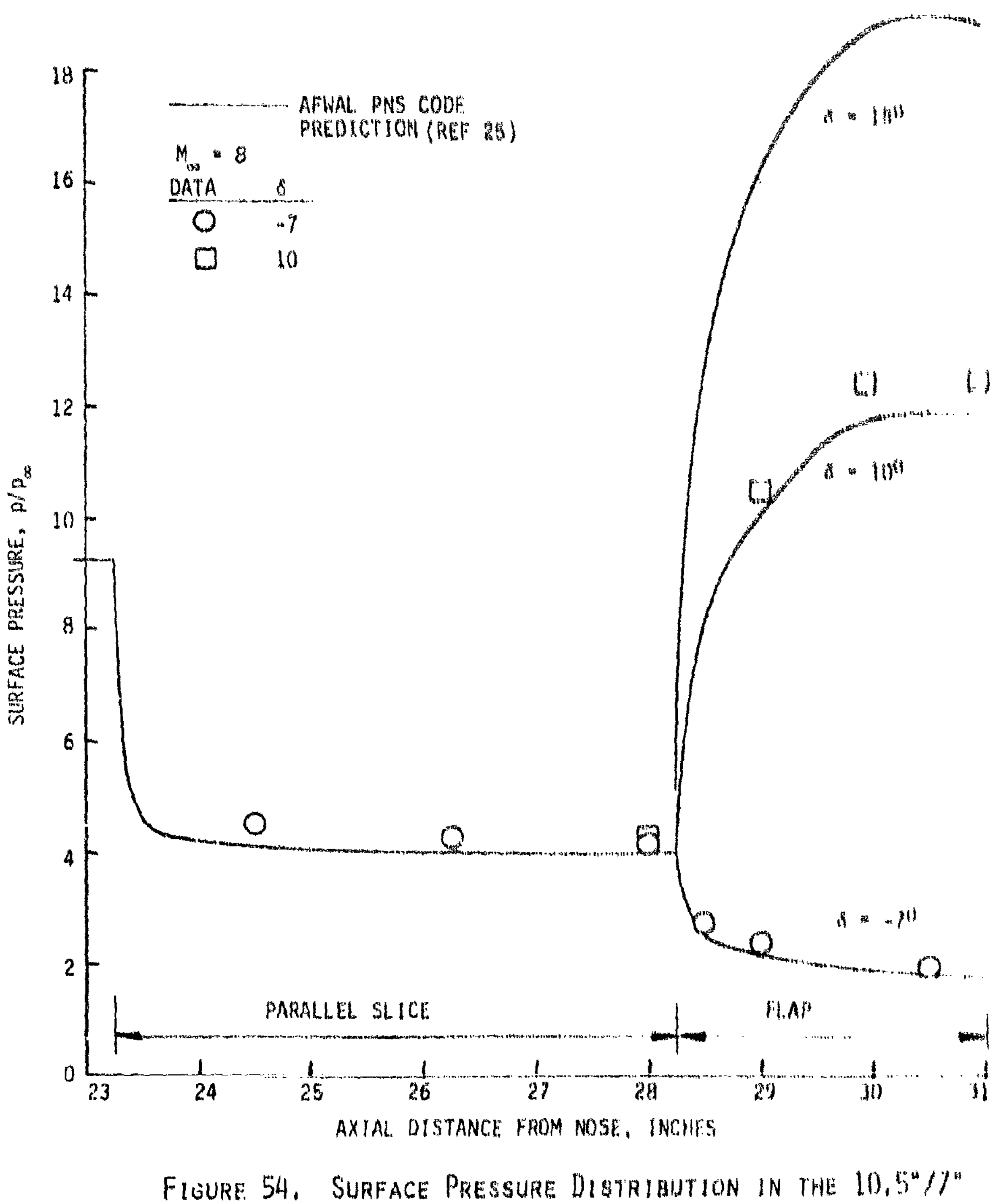


FIGURE 54. SURFACE PRESSURE DISTRIBUTION IN THE 10.5°/7° BLUNTED BICONE CONTROL REGION - α = 10°

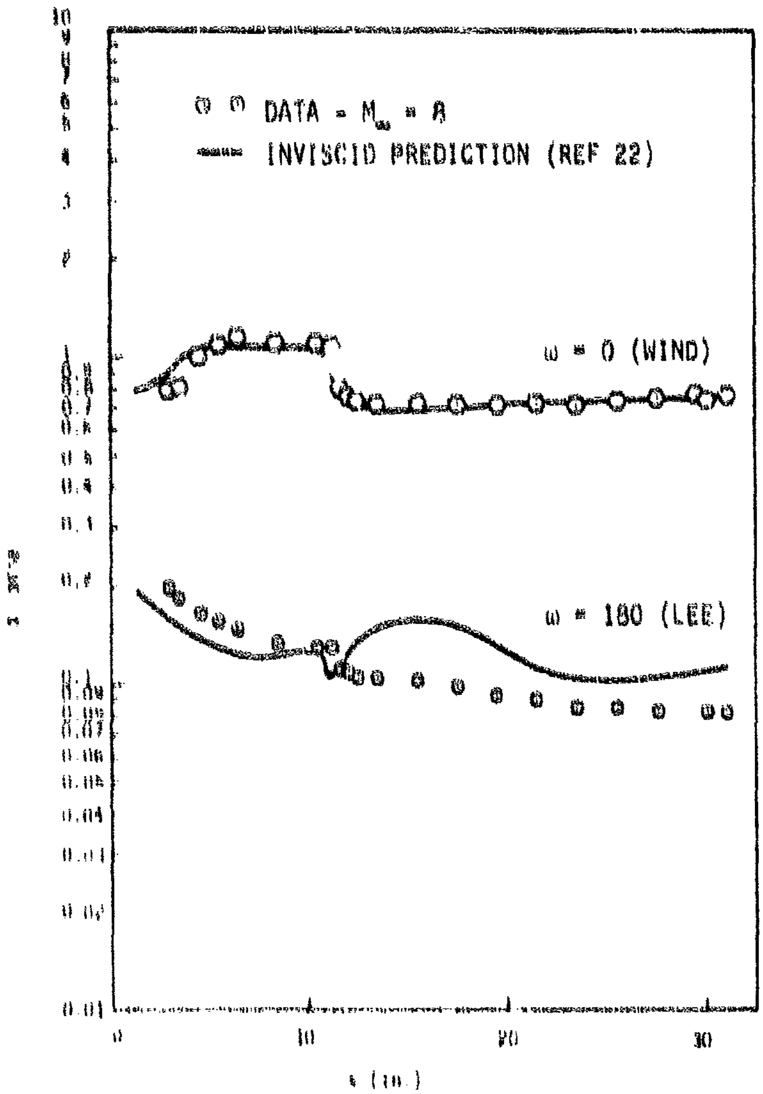


FIGURE 55. AXIAL PRESSURE DISTRIBUTION FOR THE BLUNTED 10.5°/7° BICONE AT α = 10°

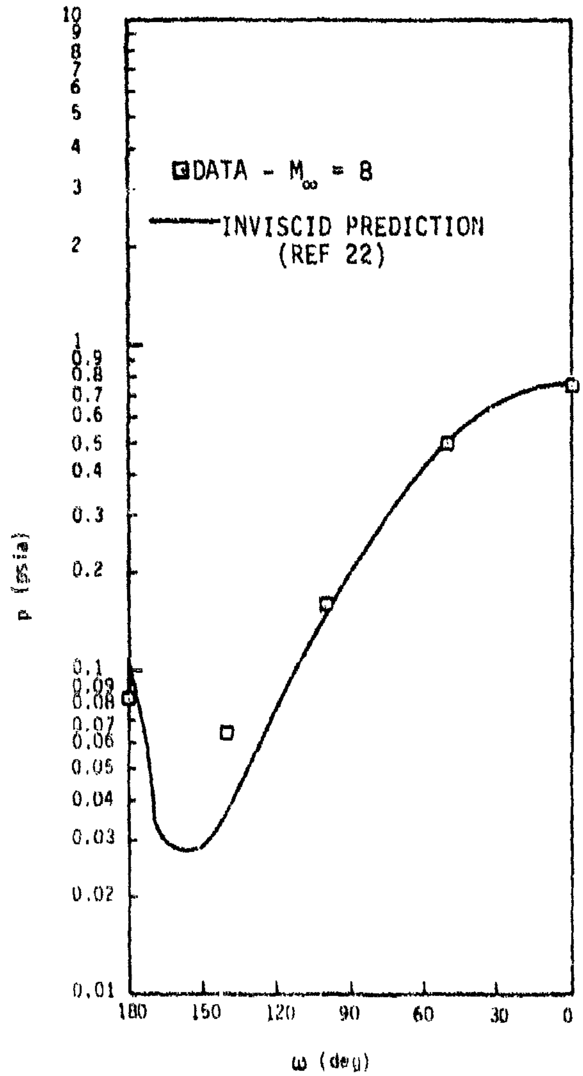


FIGURE 56. PERIPHERAL PRESSURE DISTRIBUTION FOR THE BLUNTED 10.5°/7° BICONE AT $\alpha = 10°$

than the leeside pressure, one finds than the static loads are unaffected by this poor leeside match. A word of caution here is that as M_∞ decreases, the stability at α is more sensitive to the leeside pressure because it is of the same magnitude as the windward pressure. Consequently one must model the separated flow on the leeside for good stability agreement. In this flow domain, prediction techniques such as the aforementioned PNS codes would be required.

6.2.3 Surface Heat Transfer

Heat transfer data were obtained for each of the configurations considered in this investigation. Data were obtained for laminar and turbulent flow conditions where boundary layer trips were required to promote turbulence on the blunted configurations. As mentioned earlier (see Section 2.2.4), considerable effort was expended to evaluate the minimum trip size required to promote turbulence in the forecone region. The objective was to affect the flow in the boundary layer yet have minimal effect on the shock layer flow.

Many comparisons have been made of theory with the current data, a limited quantity of which will be presented here. The objective of the few comparisons that will be shown is to demonstrate the quality of the data and to demonstrate that the trips did indeed promote turbulence. These data in concert with shock layer survey comparisons will demonstrate that the trips have minimal effects on the shock layer flow.

A comparison of the measured axial distribution of laminar surface heat transfer for the 0.5" R blunted $14^0/7^0$ bicone at $\alpha = 10^0$ with the PNS prediction of Reference 24 is shown in Figure 57. An equivalent comparison for turbulent flow on the 0.5" R blunted $10.5^0/7^0$ bicone is shown in Figure 58. It was shown (e.g., Reference 24 and Figure 52) that the surface pressure predicted by the code is in excellent agreement with the data, and it is evident from Figure 57 that

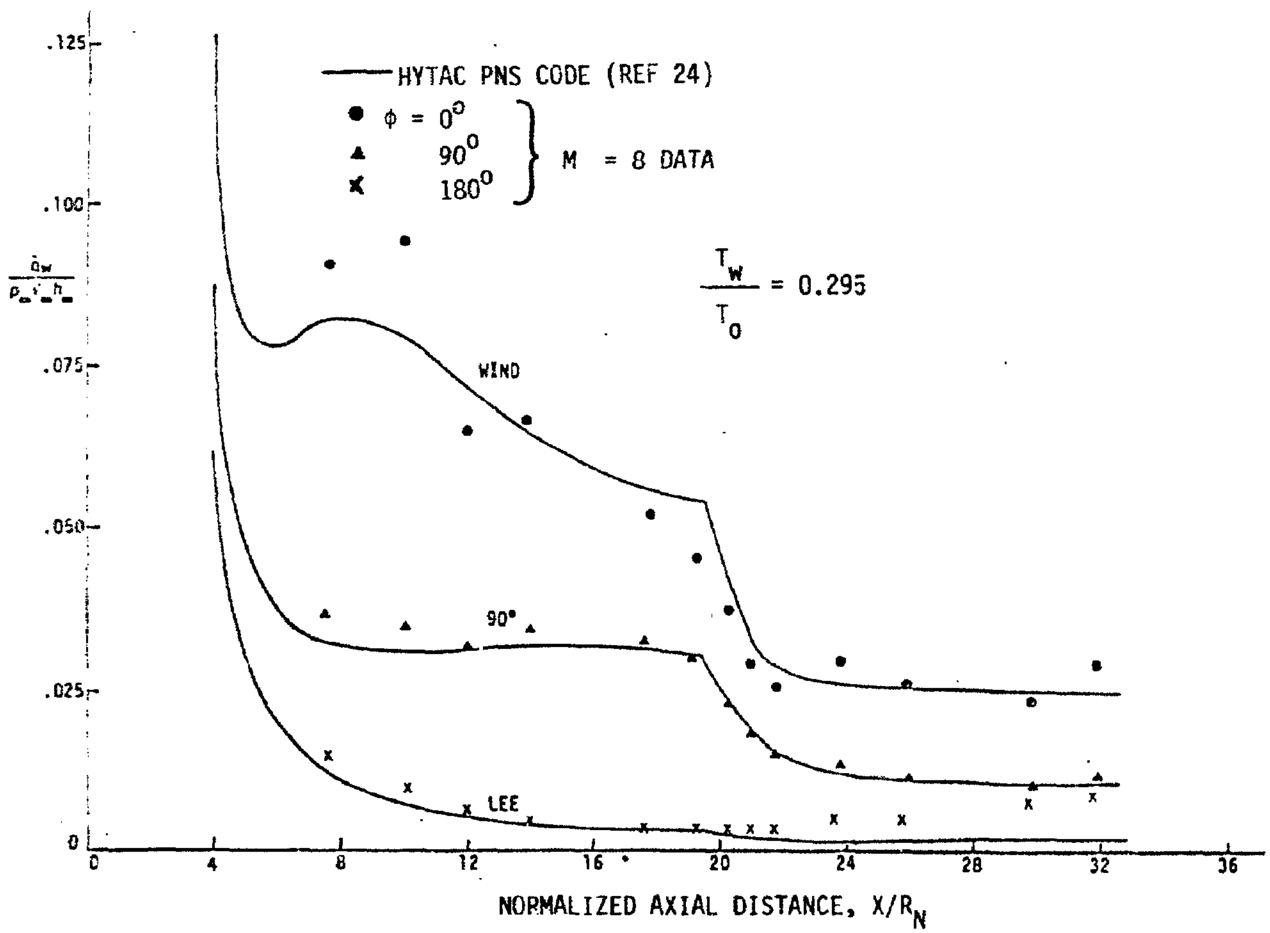


FIGURE 57. AXIAL DISTRIBUTION OF THE LAMINAR HEAT TRANSFER RESULTS FOR THE BLUNTED 14°/7° BICONE AT α = 10°

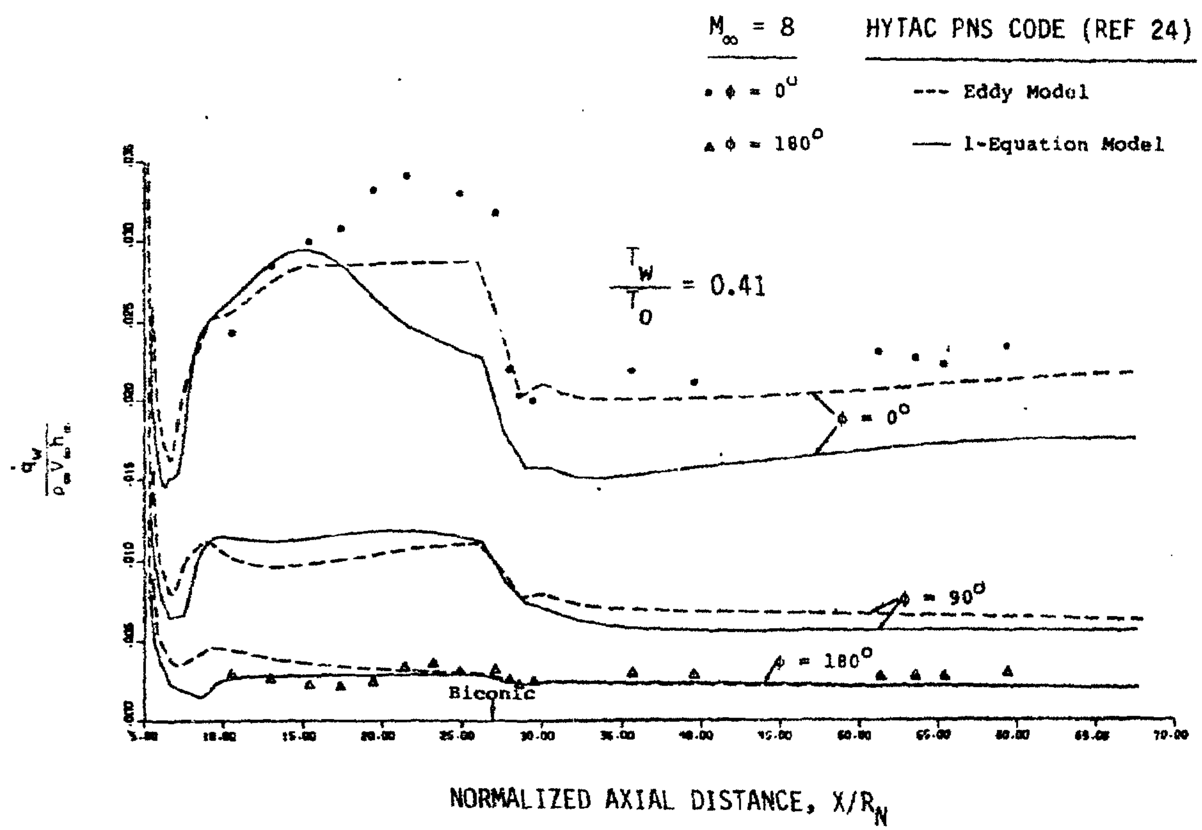


FIGURE 58. AXIAL DISTRIBUTION OF THE TURBULENT HEAT TRANSFER ON THE BLUNTED 10.5°/7° BICONE AT $\alpha = 10°$

the laminar heating is in excellent agreement with the data. In the turbulent flow case, the agreement is considered poor. Shown in Figure 58 are turbulent flow predictions for two turbulence models; one which is a mean eddy viscosity model and the second which is a one equation turbulent energy model. The reader is referred to Reference 24 for the definitions of these models. It is clear that neither of these formulations provides good agreement with the data.

Under MAT program auspices the coupling of a 3D momentum integral boundary layer code (3DMEIT - Reference 26) was coupled to the inviscid code of Reference 21 and 22. Shown in Figure 59 is a comparison of the surface heat transfer predicted by 3DMEIT with the same data shown in Figure 58 (i.e., the 0.5" R blunted $10.5^{o}/7^{o}$ bicone). One notes that the agreement between theory and data is excellent, even on the leeside where the flow is separated. It is important to note that the heating prediction on the leeside follows on a one-to-one basis the variation of the surface pressures predicted by the inviscid code (see Figure 55). A comparison of the peripheral distribution of turbulent heating predicted by 3DMEIT with the Mach 8 turbulent data is shown in Figure 60. Agreement is considered quite good.

6.2.4 Shock Layer Surveys

Considerable wind tunnel test time was expended in acquiring the shock layer survey data on the conic and biconic configurations, including the slice and flap regions. Comparisons of theory with data were made with the inviscid codes of References 21, 22, and 23, and with the PNS codes of References 24 and 25. Shown in Figure 61 are comparisons of the predicted Pitot pressure profile with the Mach 6 data for the blunted $14^{o}/7^{o}$ bicone at $\alpha = 0^{o}$. One will note that the more exact flow field code (References 21, 22) agrees well with the data in the inviscid part of the shock layer (i.e., $Z_p > .2"$) at both

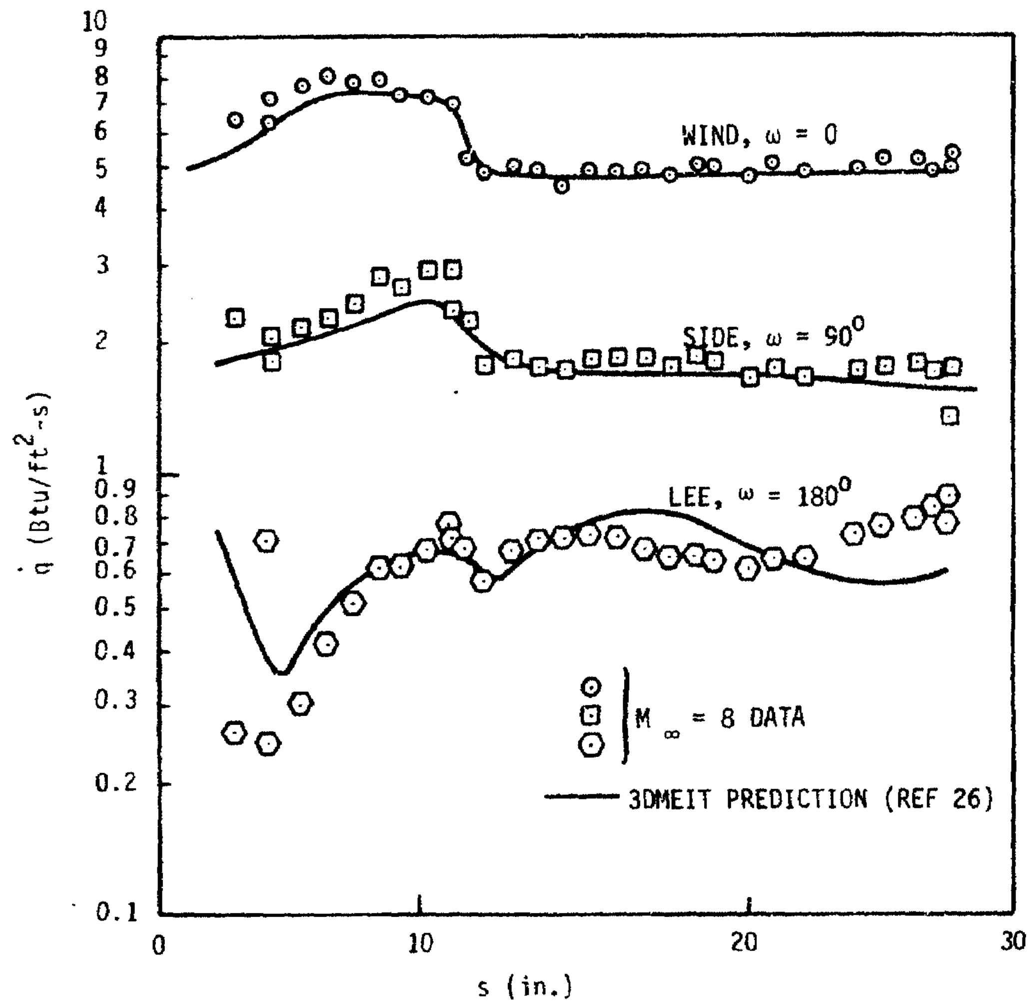


FIGURE 59. AXIAL DISTRIBUTION OF THE 3DMEIT PREDICTED TURBULENT HEAT TRANSFER FOR THE 10.5°/7° BLUNTED BICONE AT $\alpha = 10°$

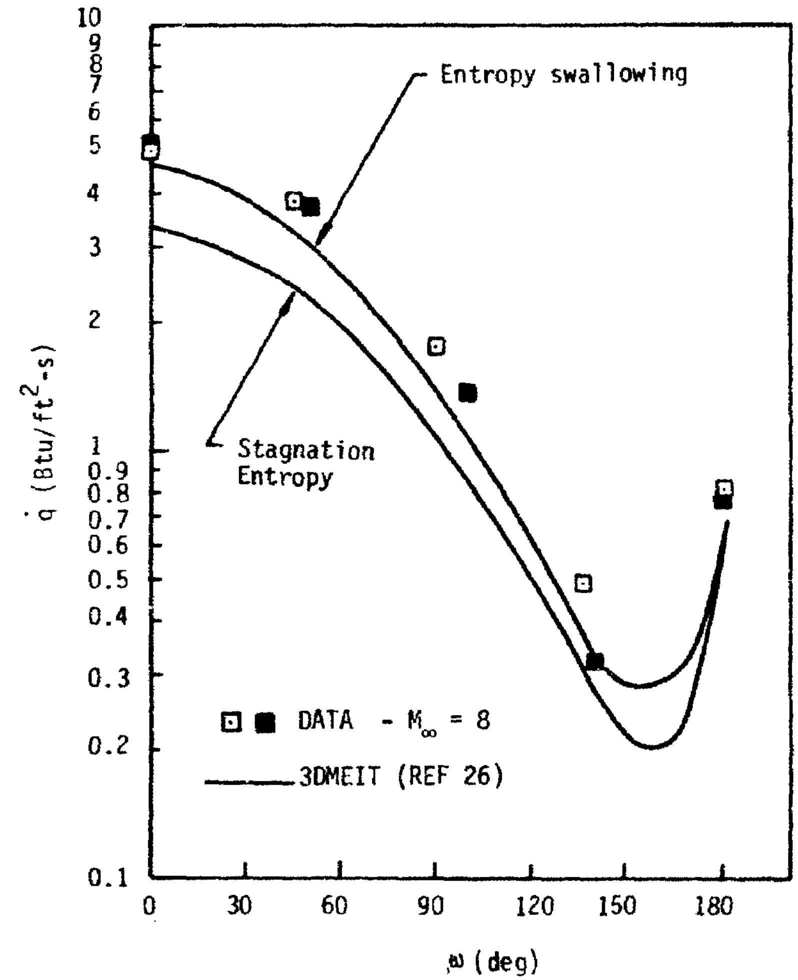


FIGURE 60. PERIPHERAL DISTRIBUTION OF THE 3DMEIT PREDICTED TURBULENT HEAT TRANSFER FOR THE 10.5°/7° BLUNTED BICONE AT α = 10° (s=30")

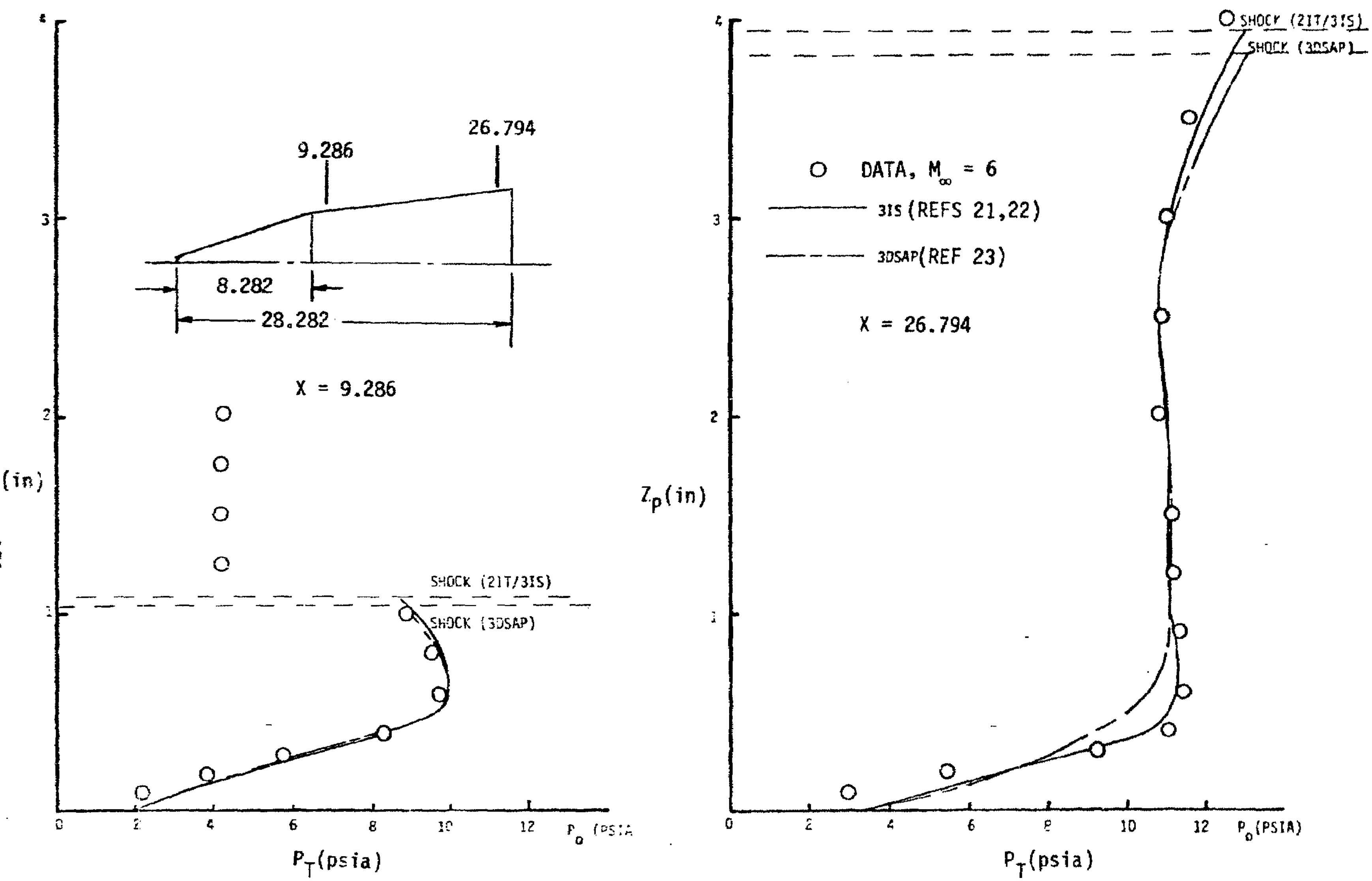


FIGURE 61. COMPARISON OF THE PITOT PRESSURE INVISCID PREDICTIONS WITH DATA FOR THE 14°/7° BLUNTED BICONE AT α = 0°

stations. The approximate method of Reference 23 provides good agreement at the forward station (x = 9.286"), which is nominally one inch downstream of the bicone juncture, however, underpredicts the pressure for $0.2 < Z_p < 1$. This was attributed to a grid resolution problem associated with the thick shock layer at this station.

Shown in Figures 62 through 64 are comparisons of the PNS code of Reference 25 with data for the blunted 7^o cone obtained at Mach 8 at $\alpha = 10^o$. The agreement between theory and data is fair on the windward side, more so in theouter parts of the shock layer than near the wall. The thermal boundary layer thickness is approximately 20 percent of the total shock layer thickness at both stations. The leeside prediction shown in Figure 64 is not in good agreement with the data. The predictions indicate a thick viscous layer with a gradient structure markedly different from that in the windward plane. However, the gradients predicted are not nearly as large as those exhibited by the data. The utility of the data here is not only to point out the prediction deficiency but also to provide sufficient quantitative information to deduce why the prediction deficiency exists.

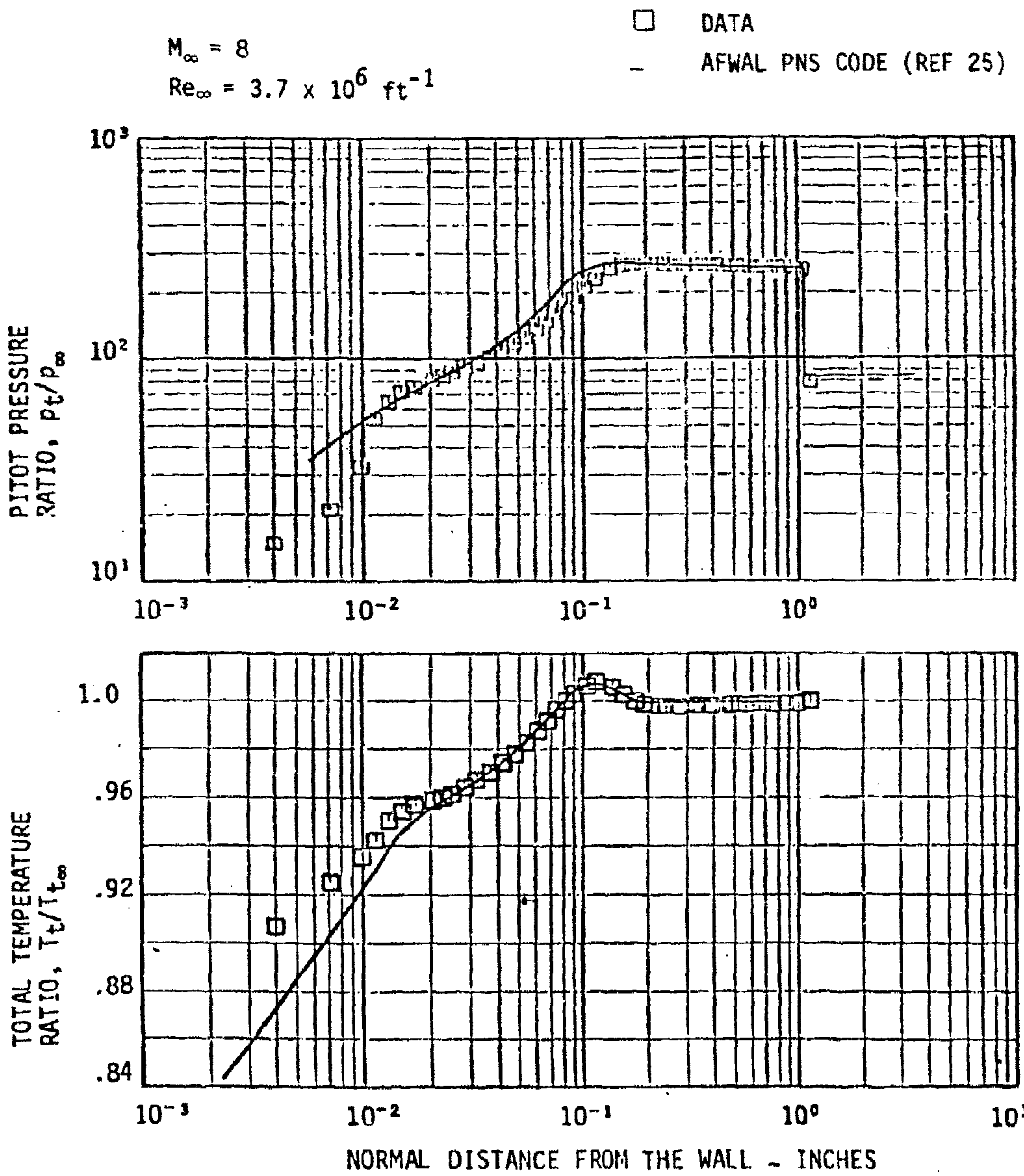


FIGURE 62. COMPARISON OF PREDICTED SHOCK LAYER PROFILES WITH WINDWARD RAY DATA FOR THE BLUNTED 7° CONE AT $\alpha = 10°$ (x = 24.4")

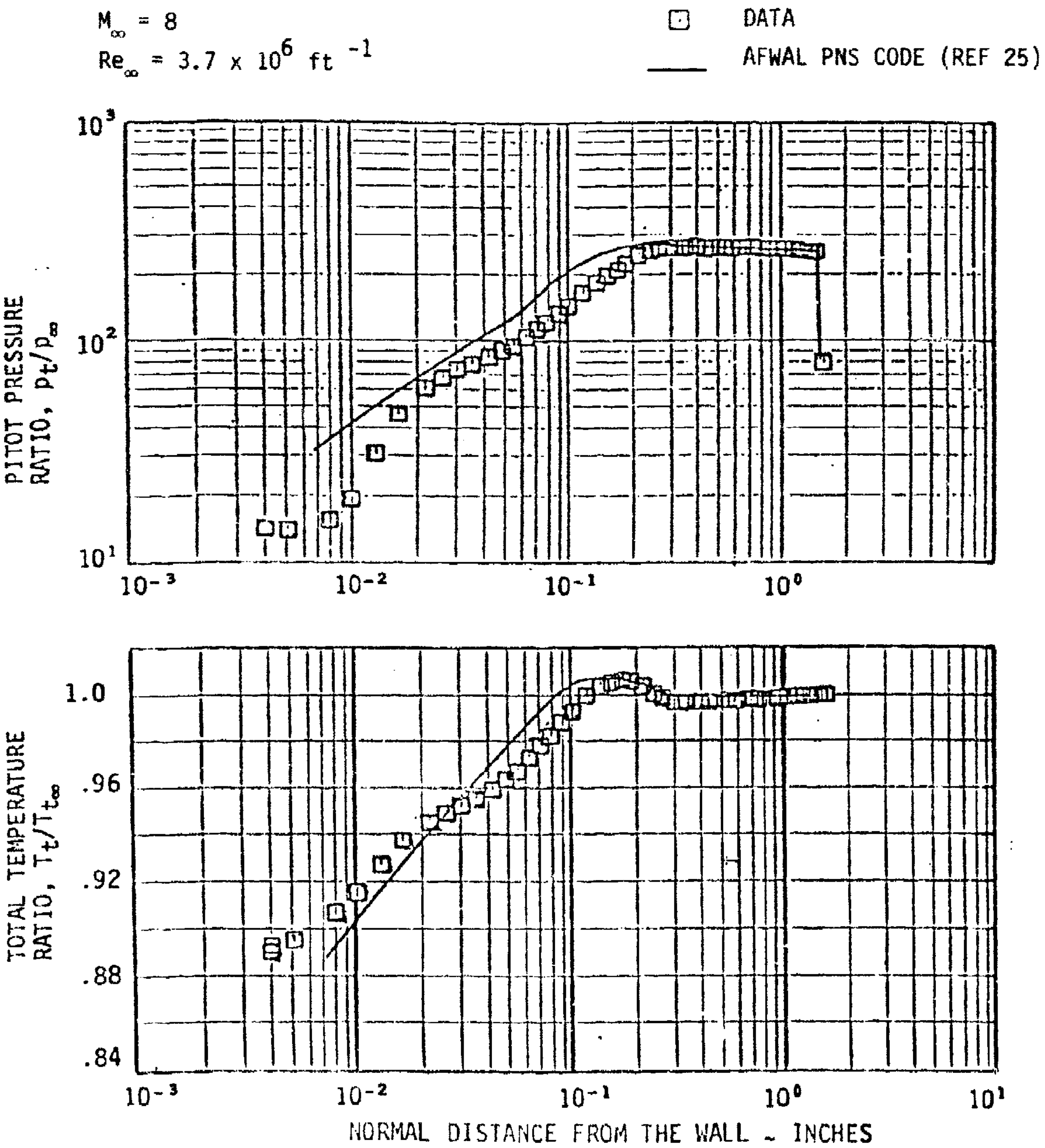


FIGURE 63. COMPARISON OF PREDICTED SHOCK LAYER PROFILES WITH WINDWARD RAY DATA FOR THE BLUNTED 7° CONE AT AT $\alpha = 10°$ (x = 34.4")

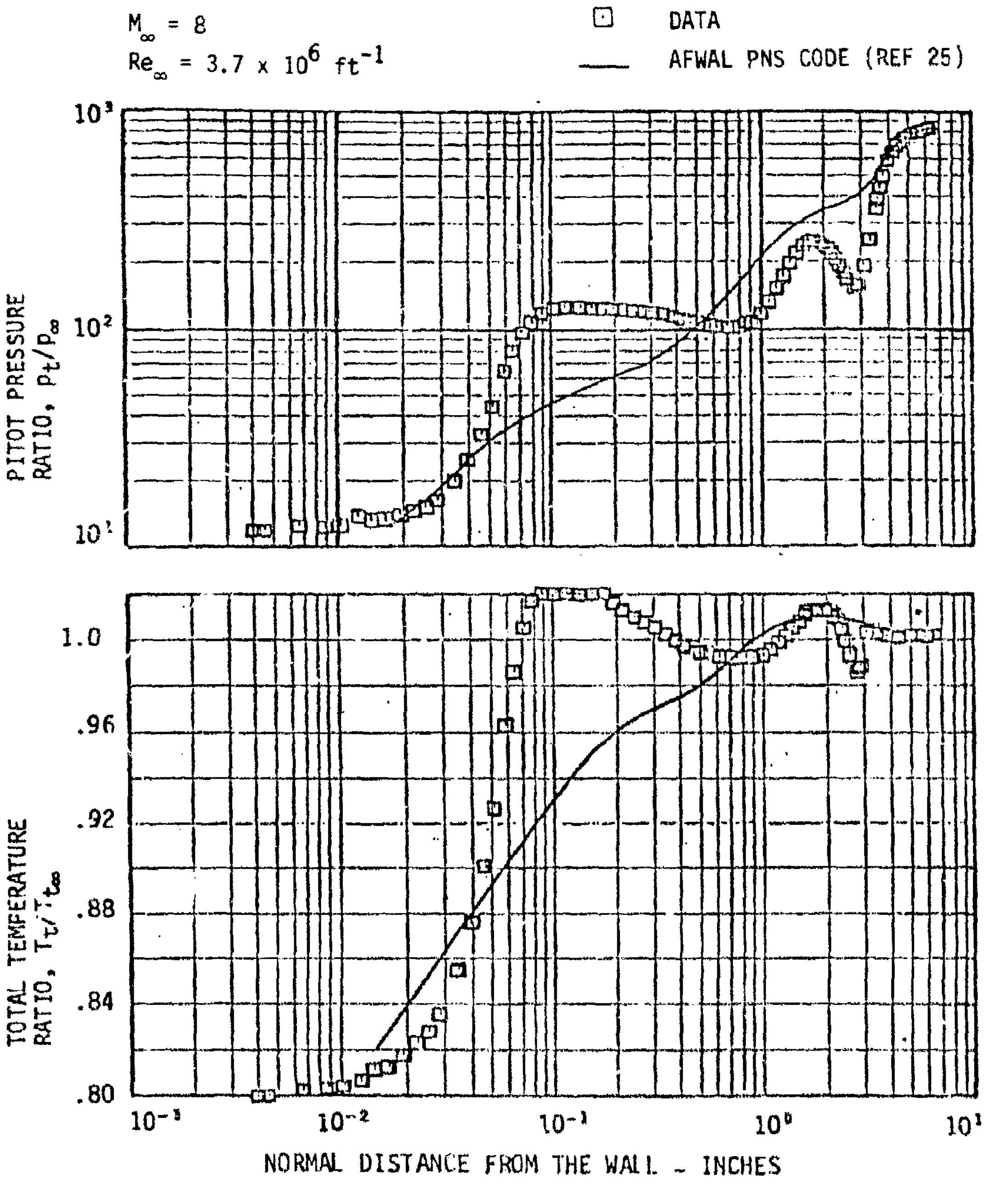


FIGURE 64. COMPARISON OF PREDICTED SHOCK LAYER PROFILES WITH LEEWARD RAY DATA FOR THE BLUNTED 7° CONE AT $\alpha = 10°$ (x = 34.4")

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APPENDIX A

DATA REDUCTION AND REPRESENTATIVE TABULAR AND GRAPHICAL PRESENTATIONS

The material contained in this appendix was excerpted from several AEDC TSRs and is included here for completeness.

A.1 Test Conditions

Freestream test conditions were evaluated using the assumption of a real gas isentropic expansion from the stilling chamber to the test section. The test conditions printed at the top of each page of tabulated data are mean values and were computed using the average stilling chamber pressure and temperature. However, the values of freestream test conditions used to normalize the data were computed from stilling chamber conditions which were recorded at the same time as the data.

A.2 Surface Heat Transfer Measurements

The high sensitivity Gardon gages used to obtain the heat transfer data are direct reading heat flux transducers whose voltage outputs may be converted to heating rate by means of a laboratory-obtained scale factor. The heat transfer coefficients were calculated using the measured heat flux (QDOT), the measured gage surface temperature (TGAGE), and the tunnel stilling chamber temperature (T0). The heat transfer coefficients were computed using:

$$H(T0) = \frac{QDOT}{T0 - TGAGE} \quad , \quad \frac{BTU}{FT^2\text{-}SEC\text{-}°R} \qquad (A.1)$$

The data were reduced from the recorded readings obtained at approximately 1.0 seconds after the model reached the tunnel centerline.

Stanton number values were computed as follows:

$$ST(INF) = \frac{H(TO)}{(RHOINF)(VINF)} \cdot \frac{TO-TGAGE}{ITO-IGAGE} \qquad \text{(A-2)}$$

where ITO and IGAGE are air enthalpy values based on TO and TGAGE, respectively.

An example of a heat transfer data tabulation is shown in Table A-1 (3 pages). The complementary graphical display of the axial heat transfer distribution for this same case is shown in Figure A-1. This corresponds to a leeside distribution at $\alpha = 10^0$. A definition of the nomenclature used in the Tables is defined in the Tabulated Data Key in the front of this report.

A.3 Model Surface Pressure

The pressure transducers were all calibrated with a known pressure differential and their readings are recorded. A zero pressure differential is applied across each transducer and the zero readings are recorded. From these data linear scale factors for each transducer for each range are calculated. Model surface pressures are calculated from differential pressure readings using the calibrated scale factors, plus a reference pressure (near vacuum) which is measured with an absolute pressure transducer.

An example of a surface pressure tabulation is shown in Table A-2 (4 pages). The corresponding graphical displays of data are shown in Figures A-2, A-3, and A-4. Although not labeled in the AEDC data book, Figures A-2 (Page 1) and A-3 (Page 2) correspond to the axial displays of P_W/P for the windward (ϕ = 0) and leeward (ϕ = 180°) sides, respectively. Figure A-4 presents meridional distributions of P_W/P at four axial stations. The stations which are displayed are unlabeled in the AEDC data book but can be reconstructed from the data tabulation. These stations are so noted in Figure A-4.

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TABLE A-1. HEAT TRANSFER DATA

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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Tw	HTC (BTU/FT2-SEC-DEGF)	STCTFI
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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TABLE 4-[illegible] TEST TRANSFER DATA (CONT'D)

[illegible]

[illegible]	[illegible]	[illegible]	WIRE RADIUS, IN.	TRIP	FLAP
[illegible]	[illegible]	[illegible]	0.500	0.033 MACHINED	10 DEG-FULL

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	STIFF2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.303E-04
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.146E-04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.885E-04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.677E-04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.371E-05
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.355E-05
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.117E-04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.121E-04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.751E-04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.773E-05
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-6.167E-06
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-2.471E-05
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-8.996E-06
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.544E-04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.353E-04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.819E-04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.307E-04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.699E-03
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.226E-03
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.384E-03
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.449E-03
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.367E-05
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-4.466E-06
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-1.879E-06
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.474E-06
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.867E-06

[illegible]

TIME= 4.94 SEC.

[illegible]

DATE COMPUTED 14-MAY-81
TIME COMPUTED 13:23:53
DATE RECORDED 1-APR-81
TIME RECORDED 1:34:33
PROJECT NUMBER V434-21

Table A-2. Heat Transfer Data (Cont'd)

			TRIP	FLAP
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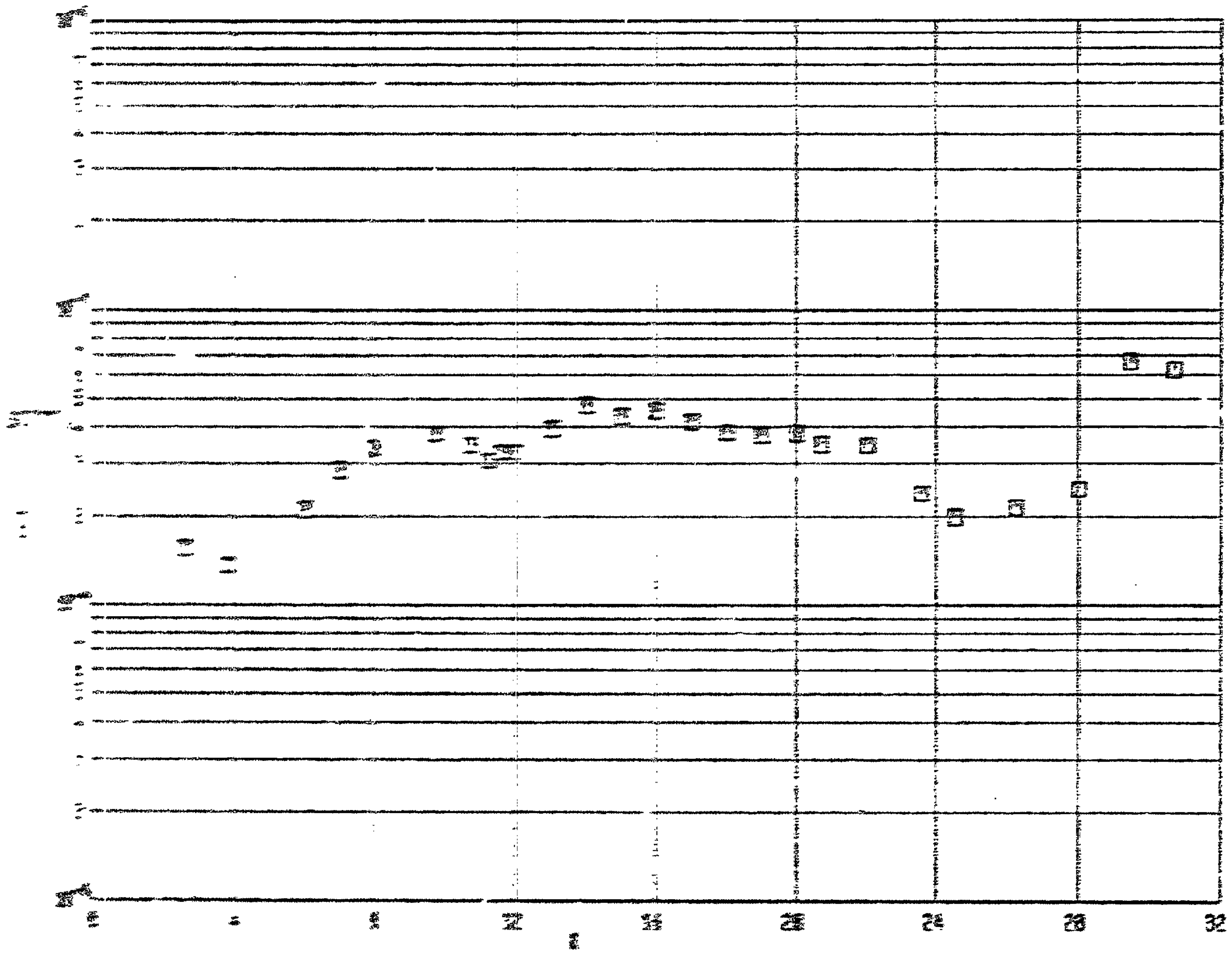
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	H(TT)	ST(TT)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.744E-04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.232E-04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.795E-03
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.572E-04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.514E-04
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

TIME= 4.94 SEC.



PAGE 1
14:25

TIME COMPUTED	08:47:30
DATE RECORDED	23-APR-81
TIME RECORDED	5:47:17
PROJECT NUMBER	C145VB

TABLE A-[illegible]. SURFACE PRESSURE DATA

[illegible]	[illegible]	TRIP	FLAP
[illegible]	[illegible]	.06 MACHINED	NONE

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	PWL/PWF	PW/PWF	EPW	TBPW (SEC)	TREC (SEC)	TDEL (SEC)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9128	1.0253	0.346	5.4	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.2559	0.9730	0.316	5.1	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.3397	0.9962	0.327	3.2	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9995	0.9996	0.001	0.5	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9454	1.0055	0.304	3.0	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0700	0.314	7.2	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.3222	0.9810	0.284	6.7	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.3459	0.7417	0.233	7.3	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.6611	0.9463	0.459	12.0	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.4366	0.5189	0.289	8.8	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.4473	0.4191	0.289	9.7	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.4346	0.4794	0.334	10.8	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.1637	0.345	21.3	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.1545	0.416	22.9	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0208	0.9831	0.946	17.2	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.2595	0.5545	0.321	13.9	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9178	0.649	17.9	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9989	1.0008	0.824	0.6	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.1067	0.9892	0.374	3.6	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.4140	0.5757	0.449	13.7	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9998	0.9994	-0.015	0.5	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9986	0.9994	0.001	0.5	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9994	0.9991	-0.041	0.6	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9985	1.0006	0.034	0.6	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9987	0.011	0.6	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9977	1.0008	0.034	0.6	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9997	0.9987	-0.015	0.9	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9987	0.9993	0.005	0.6	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.2274	0.5692	0.372	17.5	11.7	10.0

DATE COMPUTED [illegible]
TIME COMPUTED 08:47:50
DATE RECORDED 23-APR-81
TIME RECORDED 5:47:17
PROJECT NUMBER C145VB

TABLE I-1. SURFACE PRESSURE DATA (CONT'D)

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[illegible]	[illegible]	.06 MACHINED	NONE

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	PWL/PWF	PW/PWT	KPW	TNPW (SEC)	TREC (SEC)	TDEL (SEC)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.1932	0.6717	0.381	17.2	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.4431	0.3794	0.354	12.3	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.2229	0.5919	0.415	19.3	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0595	0.5447	0.442	13.3	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9612	1.0201	0.198	3.7	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9903	1.0716	0.641	1.0	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9995	1.0097	0.090	1.0	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9998	1.0067	0.045	0.7	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9999	1.0006	0.057	0.8	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0114	0.9914	0.132	27.3	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.1649	0.4503	0.305	21.2	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0145	0.9993	1.067	29.2	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.4491	0.5216	0.479	15.7	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.1169	0.4296	0.461	21.9	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9985	0.9990	-0.650	1.0	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9995	0.9997	-0.634	1.0	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9997	1.0062	0.820	0.8	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9992	0.9994	-0.034	1.0	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9977	0.9964	0.677	1.1	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9992	1.0106	0.115	1.1	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9993	0.9995	0.004	0.9	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9990	1.0016	0.025	0.9	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9988	1.0000	0.255	1.4	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9979	1.0007	0.085	1.5	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9976	0.9999	0.184	1.5	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9947	0.9994	0.267	1.6	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9982	1.0034	0.113	1.7	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9993	0.9996	0.005	1.0	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9993	0.9952	-0.616	1.0	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0479	1.0019	-0.618	1.4	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0175	1.0024	-0.616	32.4	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.1221	0.7278	0.438	25.1	11.7	10.0

[illegible]

Table A-2. Surface Pressure Data (Cont'd)

DATE COMPUTED 3-JUN-81
TIME COMPUTED 08:47:50
DATE RECORDED 23-APR-81
TIME RECORDED 5:47:17
PROJECT NUMBER C145VB

[illegible]

TRIP .05 MACHINED

FLAP NONE

[illegible]

TAP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	KPW	TMPW (SEC)	TREC (SEC)	TDEL (SEC)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.6117	0.8624	0.108	28.9	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.6541	0.8416	0.369	27.7	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.7031	0.2514	0.476	13.3	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.7738	0.1720	0.490	13.2	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9943	0.9988	-0.599	1.8	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9993	0.9986	-0.155	1.7	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9986	1.0000	0.110	1.7	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9964	0.9992	-0.601	2.0	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9993	0.9991	-0.034	2.0	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9984	1.0020	0.041	1.9	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9962	1.0002	0.107	1.2	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.6609	0.0417	0.379	11.6	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.6943	0.1898	0.472	13.6	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.5356	0.2022	0.377	11.3	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.6125	0.1228	0.458	13.7	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.7292	0.1469	0.437	12.3	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.7139	0.2081	0.454	12.7	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.6712	0.2644	0.464	13.1	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9129	1.0743	0.529	16.0	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9616	1.0022	0.477	3.8	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9424	1.0005	0.392	2.8	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9759	1.0504	0.170	1.9	11.7	10.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.6511	0.2364	0.412	12.7	11.7	10.0

[illegible]	[illegible]	V =	3081.8 FT/SEC
[illegible]	[illegible]	P =	3.089 PSIA
[illegible]	[illegible]	T =	95.6 DEGF
[illegible]	[illegible]	PT2 =	7.19 PSIA
[illegible]	[illegible]	RHO =	2.391E-03 LBM/FT3
[illegible]	[illegible]	C.B.=	24.00 IN

DATE COMPUTED 3-JUN-81
TIME COMPUTED 08:47:51
DATE RECORDED 23-APR-81
TIME RECORDED 5:47:17
PROJECT NUMBER C145TB

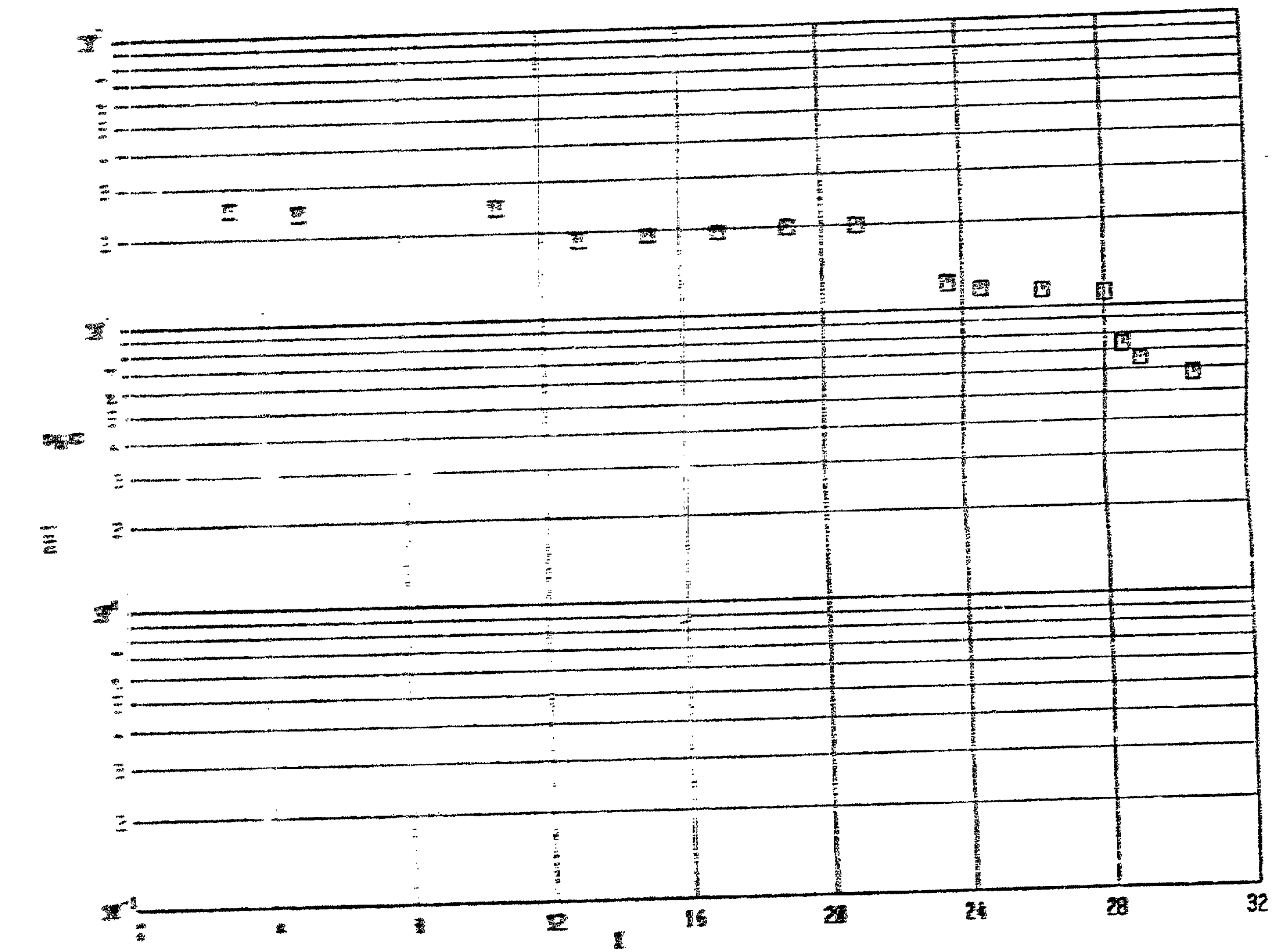
[illegible]

TABLE A-1. SURFACE PRESSURE DATA (CONT'D)

[illegible]	NOSE RADIUS, IN	TRIP	FLAP
[illegible]	0.5000	.86 MACHINED	NONE

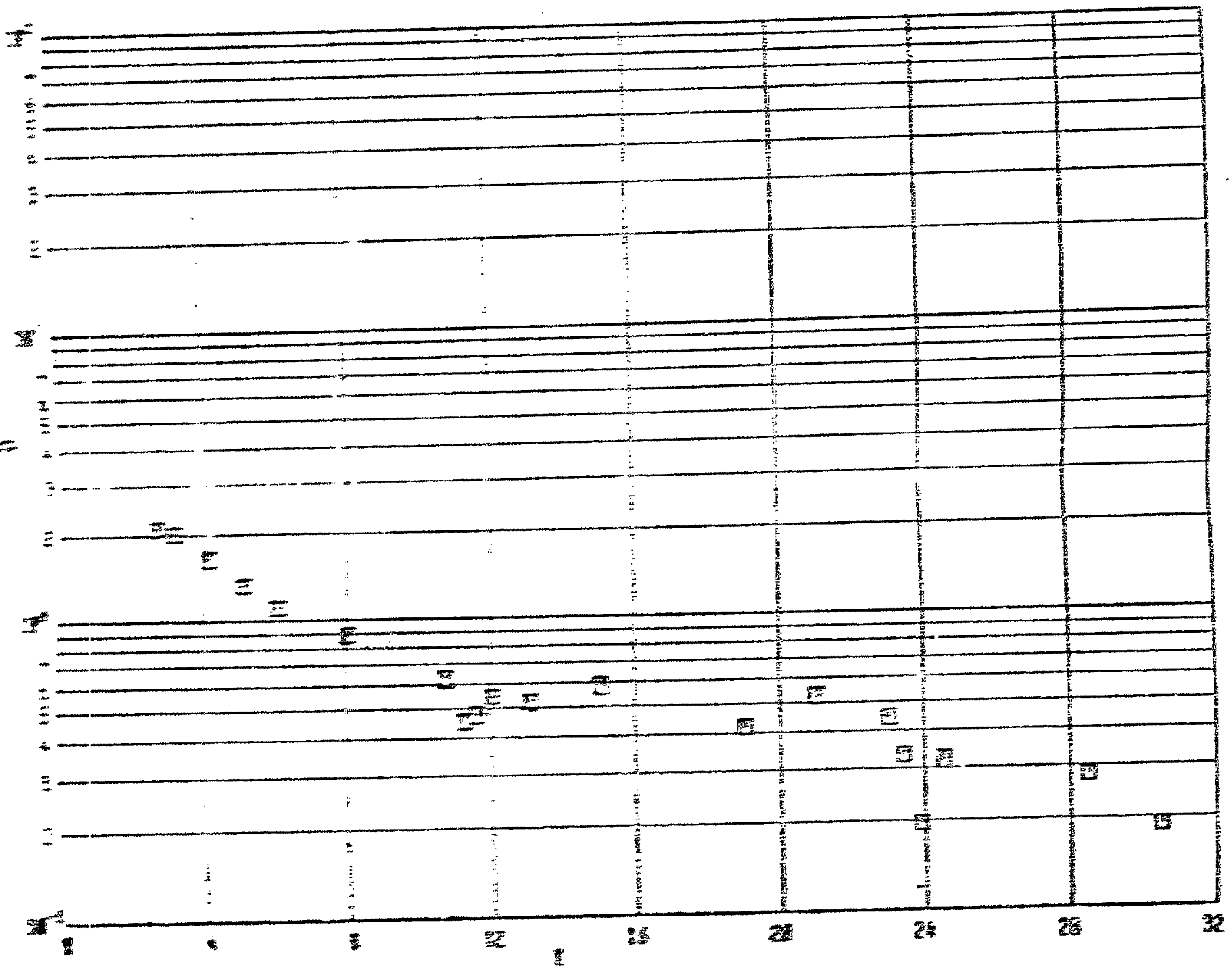
[illegible]

[illegible]	TG106 TG108	TG110 TG112	TG114 TG116	TG118 TG120	TG122
[illegible]	1226.		1155.	1195.	1186.
[illegible]	1229.		1173.	1195.	1186.
[illegible]	1213.		1196.	1199.	1193.
[illegible]	1225.		1200.	1204.	1195.
[illegible]	1226.		1203.	1206.	1198.
[illegible]	1224.		1205.	1208.	1201.

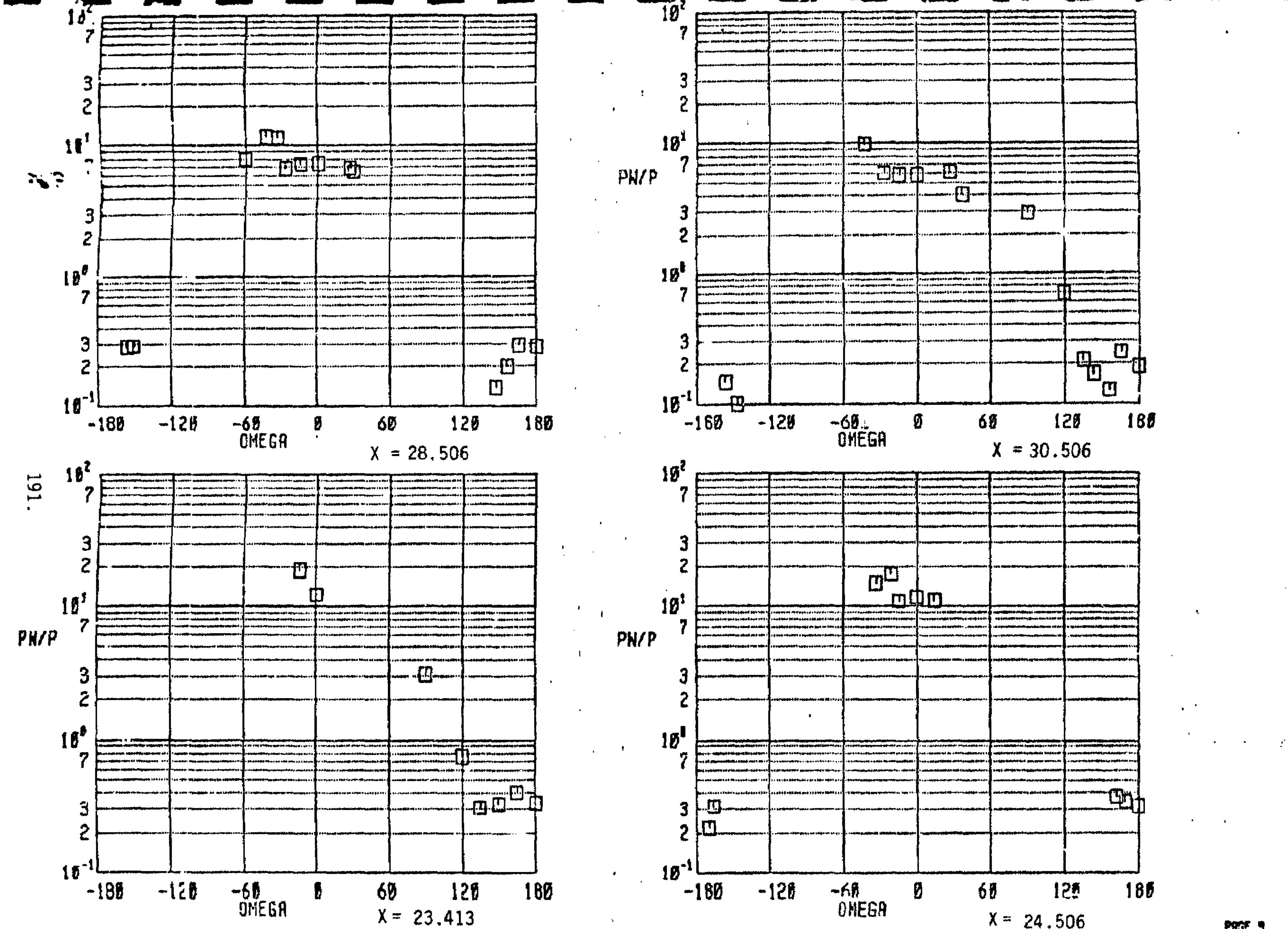


[illegible] Figure A-1. Surface Pressure Data ([illegible], = 20°) [illegible]

PAGE 1
17-JUL-81
09:21



SURFACE PRESSURE DATA



RUN 032 Figure A-4. Surface Pressure Data (MERIDIONAL, $\alpha = 20^{o}$) BMO/SAI MAT PHASE I

A.4 Shock Layer Surveys

Surveys of the boundary layer and shock layer were made at several stations on the body, generally in a body normal mode. Where it was not possible to probe in a local surface normal mode, due to hardware restrictions, it is so noted in the AEDC data tabulations. For the majority of the surveys, the Pitot, total temperature, and Preston tube were located on one probe head and the Mach/Flow Angularity probe on a separate holder. Thus for the multi-probe head, the first step in the data sequence was to obtain the surface shear - i.e., the Preston tube data. Once these data were obtained, the probe holder was moved incrementally upward off of the model surface and flow field survey data were obtained.

A.4.1. Preston Tube Data

Model wall shear stress and the corresponding skin friction coefficient were calculated using the Preston tube pressure relationships first described by Preston (Reference 13). The shear stress was calculated by an iterative process, using calibration curve fits and boundary layer equations. A flow chart defining the data reduction procedure is shown in Figure A-5.

The calibration coefficients presented in this figure are based on previously published results (References 11, 14, and 15) and data obtained at AEDC that are yet to be published. The calibrations are considered valid over an RT and MT range of 5 to 1000 and 0 to 0.15, respectively. As indicated earlier, the shear stress and skin friction coefficient were calculated for the first point in a survey only, when the Preston tube was flush against the model surface.

Major Equations

$$MT = \sqrt{TAUX/RHOW}/AW$$

$$RT = (D)\sqrt{(TAUX)(RHOW)}/MUW$$

$$PTAU = (PPRESS - PWX)/TAUX$$

$$FRA = 1 - E5(RT)^{E6}$$

$$G = e^{\left[E1(\ln RT) + E2 + ((E3)(\ln RT) + E4)/(1 - (E5)(RT)^{E6})\right]}$$

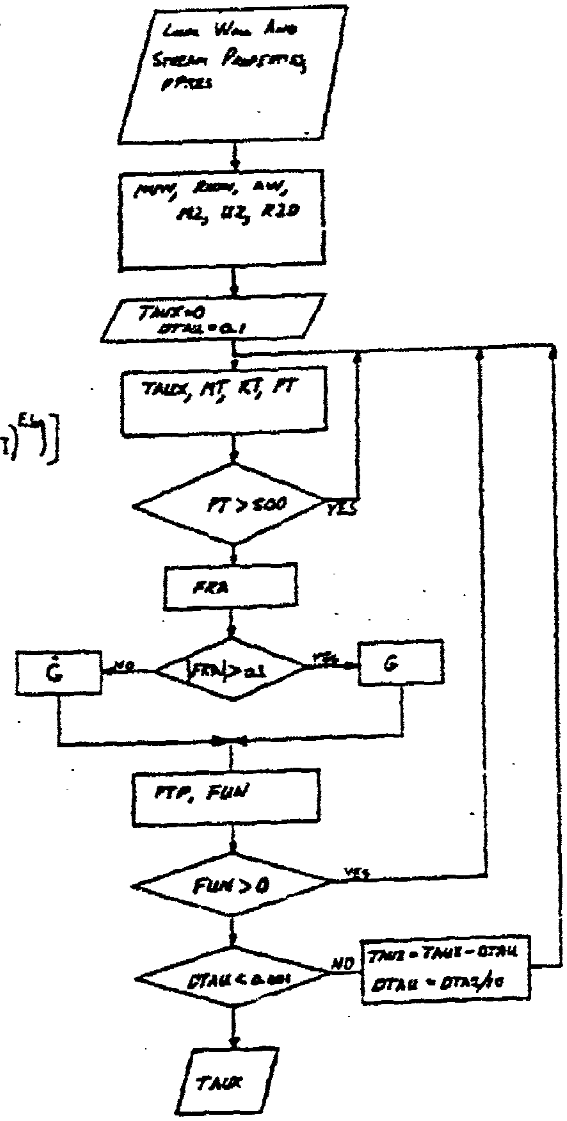
$$\dot{G} = e^{\left[(E1)(\ln RT) + E2 - E3/(E5)(E6)\right]}$$

$$FUN = -RT + CC1(PTP) +$$

$$CC2\left[e^{F} - 1 - F - \frac{F^2}{2} - \frac{F^3}{6}\right]$$

where $F = (CC3)(PTP)$

$$PTP = PTAU - MT^2(G)$$



Coefficients

$CC1 = 0.43473$
$CC2 = 11.285$
$CC3 = 0.02354$

$E1 \rightarrow E6 = 0.343, 8.243, 2.657, -8.193, 0.00346, 1.94$

NOTE: FOR A DEFINITION OF THE NOMENCLATURE SEE THE "TABULATED DATA KEY" IN THE FRONT OF THIS REPORT.

FIGURE A-5. PRESTON TUBE DATA REDUCTION FLOW CHART

A.4.2. Shock Layer Survey Data

Probe locations within a survey are presented as heights above the model surface measured along the direction of the traverse, and coordinate values are given in terms of the model axis system. Corrections have been included for the fact that the Pitot probe was sometimes slightly deflected at the model surface.

Mach/Flow-Angularity probe pressures (P1, P2, P3, P4, P5) and the Pitot pressure (PP) were computed using the equilibrium pressure prediction technique presented in Reference 12. The technique uses a mathematical model of the pressure lag/time history and fits the pressure history with a least squares curve fit to predict equilibrium pressure. The basic assumption is that the pressure measured at the transducer exponentially approaches the equilibrium pressure at the orifice. It is also assumed that the orifice pressure is a constant, during the time when the transient data were recorded. Inputs to the curve fit routine are: (1) slip flow coefficient and (2) pressure-time data. The data reduction equations for predicting equilibrium pressure from transient data as follows (from Reference 12).

Slip Flow Coefficient:

$$A = 1.776\ (10^{-6})\ \left(\begin{matrix}\text{Mean tube}\\ \text{temperature}\end{matrix}\right) / \left(\begin{matrix}\text{Tube}\\ \text{I.D.}\end{matrix}\right)$$

$$\left.\begin{matrix}\text{Mean tube temperature} = 1200^{\circ}\text{R, assumed}\\ \text{Tube ID} = 0.012\text{ in., smallest diameter}\\ A = 0.18\text{ psi, (only rough estimate required)}\end{matrix}\right\}\ \text{For these tests}$$

Pressure-Time Data:

Pi ~ Transducer pressure of data point, i, psia (computed in same manner as model surface pressures)

ti ~ Time of data point i, sec.

n ~ Total number of data points

Slope of Pressure-Time Data:

$$\frac{dPi}{dt} \sim \text{Local slope} = \frac{P_{(i+m)} - P_{(i-m)}}{2m\Delta t}\text{, psi/sec}$$

where Δt = time between successive data points, sec

m = integer smoothing function = 1 for this test.

With the above inputs (A, Pi, dPi/dt) the following computations are made to evaluate (or predict) the equilibrium pressure (P_e).

$$Ci = (Pi)^2 + APi \tag{A-3}$$

$$K = n\,\frac{\left\{\sum_{i=1}^{n} \frac{dPi}{dt}\cdot Ci\right\} - \left\{\sum_{i=1}^{n} \frac{dPi}{dt}\right\}\left\{\sum_{i=1}^{n} Ci\right\}}{\left\{\sum_{i=1}^{n} Ci\right\}^2 - n\left\{\sum_{i=1}^{n} (Ci)^2\right\}} \tag{A-4}$$

$$D = \left\{K \sum_{i=1}^{n} Ci + \sum_{i=1}^{n} \frac{dPi}{dt}\right\} /n \tag{A-5}$$

$$P_e = \frac{-A}{2} + \sqrt{\left(\frac{A}{2}\right)^2 + \frac{D}{K}}\text{, psia} \tag{A-6}$$

The prediction technique fails whenever there is an insufficient sample of transient data with which to evaluate the constant K. In fact K is undefined for the case where the pressure, Pi, is constant. To alleviate this problem a check was made, based on the value of K for this test.

If $0.05 < K < 3$, the predicted pressure was used, otherwise the final measured value was used.

There were a few instances wherein the transient data were changing so rapidly for this test that the calculated value of dPi/dt was inaccurate for the first points of the pressure-time history. Whenever this happened the initial transient data adversely affected the prediction, giving inaccurate results. To alleviate the problem initial data points were dropped from the curve fit; one point was dropped at a time and P_e was recomputed and compared to the last computed value. The iteration ended whenever the change in the predicted pressure was less than two percent, or more than four data points were dropped. It should be noted that the inaccuracy in dPi/dt can be eliminated by taking data at a faster rate or by delaying the beginning of the data record. For early tests the data acquisition rate was limited to 0.6 sec per point, for the majority of the test program. Improvements in the data acquisition system permitted taking the same type of data at a significantly faster rate (up to 10 points per sec) in later tests.

Figures A-6 and A-7 contain typical results from the equilibrium pressure prediction program.

Local Mach number and flow angle are computed from pressure P1 trhough P5 using curve-fitted calibration data. Extensive calibration data have been obtained on similar probes and these data have been correlated against the parameters DPSQP and PAVGP5 which are defined as:

$$\mathrm{DPSQP} = \sqrt{(\mathrm{P1}-\mathrm{P3})^2 + (\mathrm{P2}-\mathrm{P4})^2}/(2 \cdot \mathrm{P5}) \qquad \text{(A-7)}$$

and

$$\mathrm{PAVGP5} = \mathrm{PAVG}/\mathrm{P5} = (\mathrm{P1} + \mathrm{P2} + \mathrm{P3} + \mathrm{P4})/(4 \cdot \mathrm{P5}) \qquad \text{(A-8)}$$

For the present tests, calibration data were obtained with the Mach/Flow-Angularity probe (identified as Probe #4) in the tunnel freestream and these data were combined with previous calibrations obtained on a similar probe at Mach number 1.5 through 5.0. The combined data set was curve fitted and the curve fits were used in the data reduction. The calibration data and

the curve fits are shown in Figures A-8a and A-8b where the actual data reduction equations are as follows:

Local Mach Number:

$$MLC = e^{[AK + BK(DPSQP)^2 + CK(DPSQP)^4]}$$

$$\text{where} \quad AK = \sum_{i=0}^{5} [AM_i \, (\ell nPAVGP5)^i]$$

$$BK = \sum_{i=0}^{4} [BM_i \, (\ell nPAVGP5)^i]$$

$$CK = \sum_{i=0}^{4} [CM_i \, (\ell nPAVGP5)^i]$$

Total Angle of Attack:

$$AATCA = (DPSQP)\ [D1 + D2\ell n(MLC) + D3(\ell n(MLC))^2]$$
$$+ [D4 + D5(\ell n(MLC))^2]\ (DPSQP)^{D6} \quad , \ \deg$$

Curve Fit Coefficients:

AM0-5 = 3.6474, 10.8249, 12.5254, 5.90988, 1.03548, 0

BM0-4 = 7.54593, 0, -16.5279, 0, 8.66794

CM0-4 = -108.870, 0, 182.245, 0, -37.4971

D1-D6 = 121.044, 18.6043, -74.2038, -37.4837, 58.2593, 0.872233

Radial Angle: (Not a Curve Fit)

$$PHI = \tan^{-1}\left(\frac{DP24}{DP13}\right) + 90\left(\frac{1+DP13}{|DP13|}\right) \ , \ \deg$$

If PHI < 0 then PHI = PHI + 360.

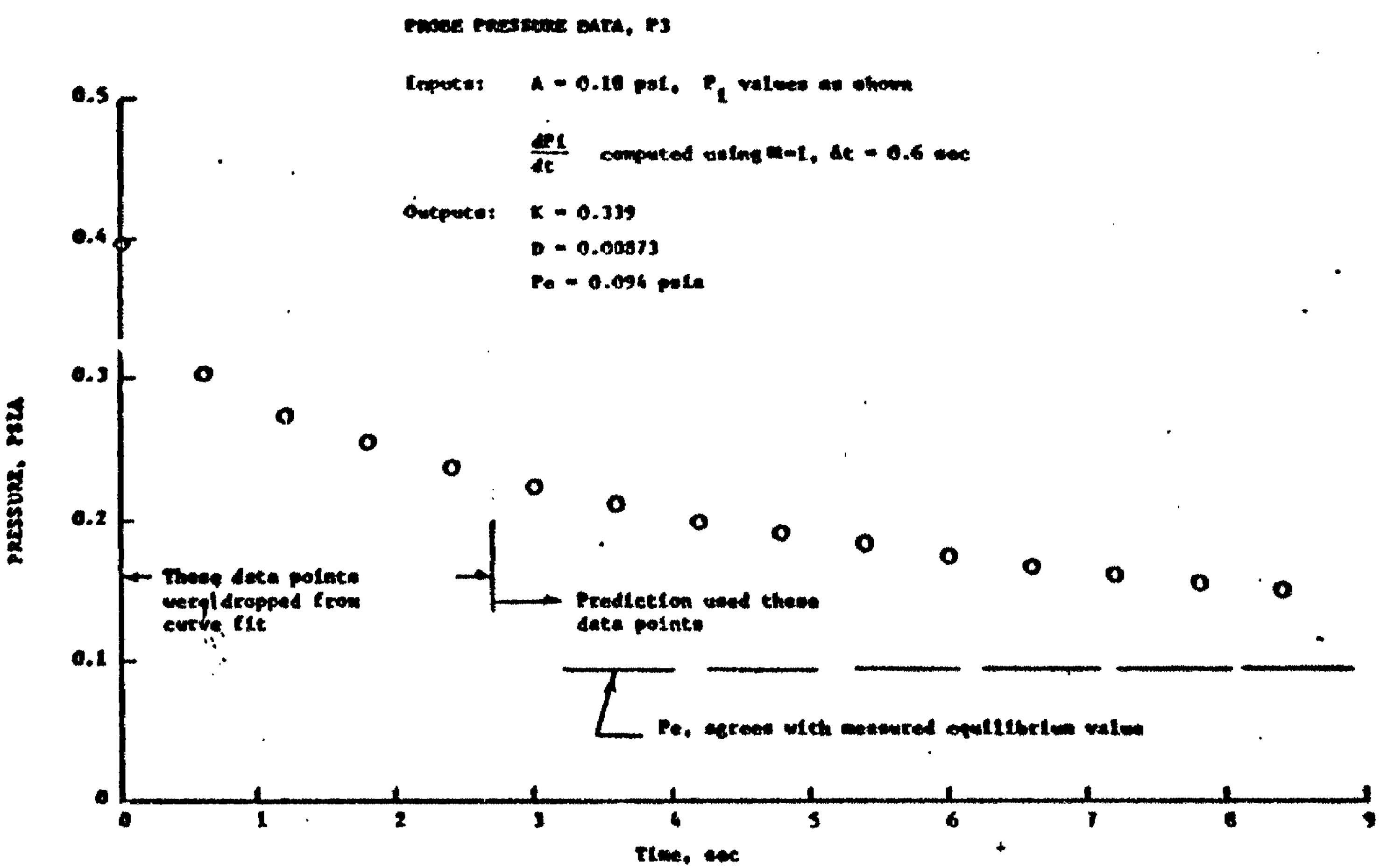


FIGURE A-6. TYPICAL PREDICTION PROGRAM RESULTS (PROBE PRESSURE)

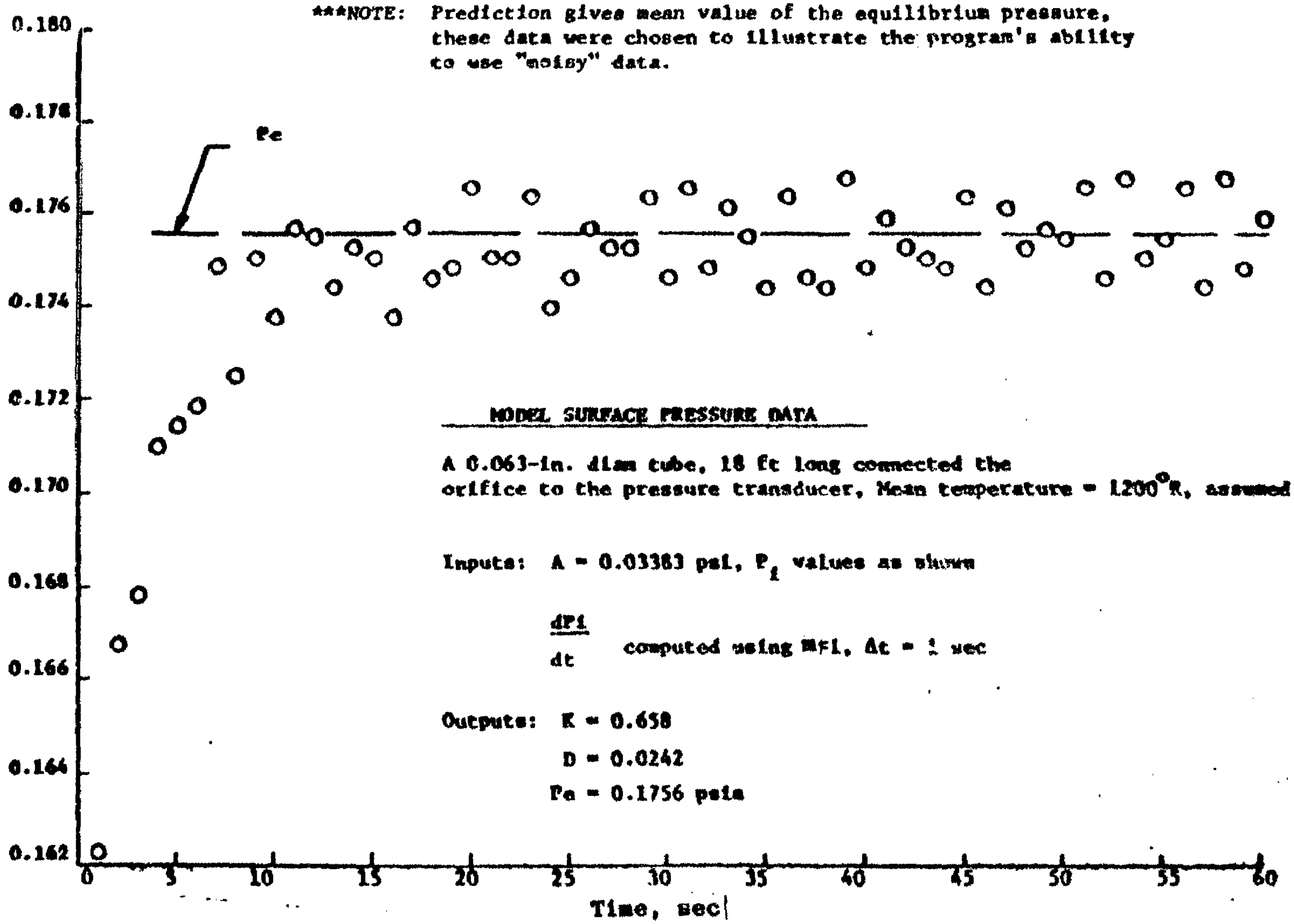
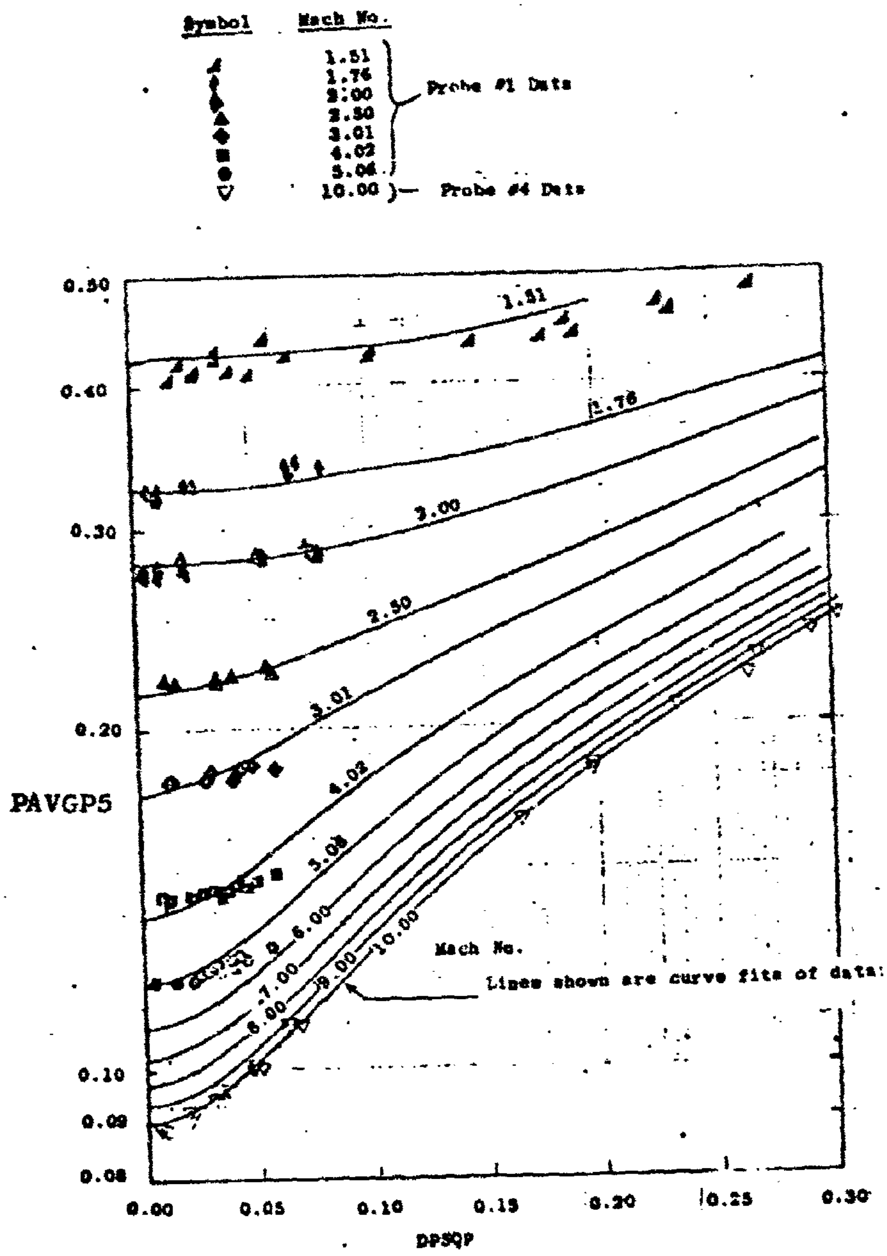
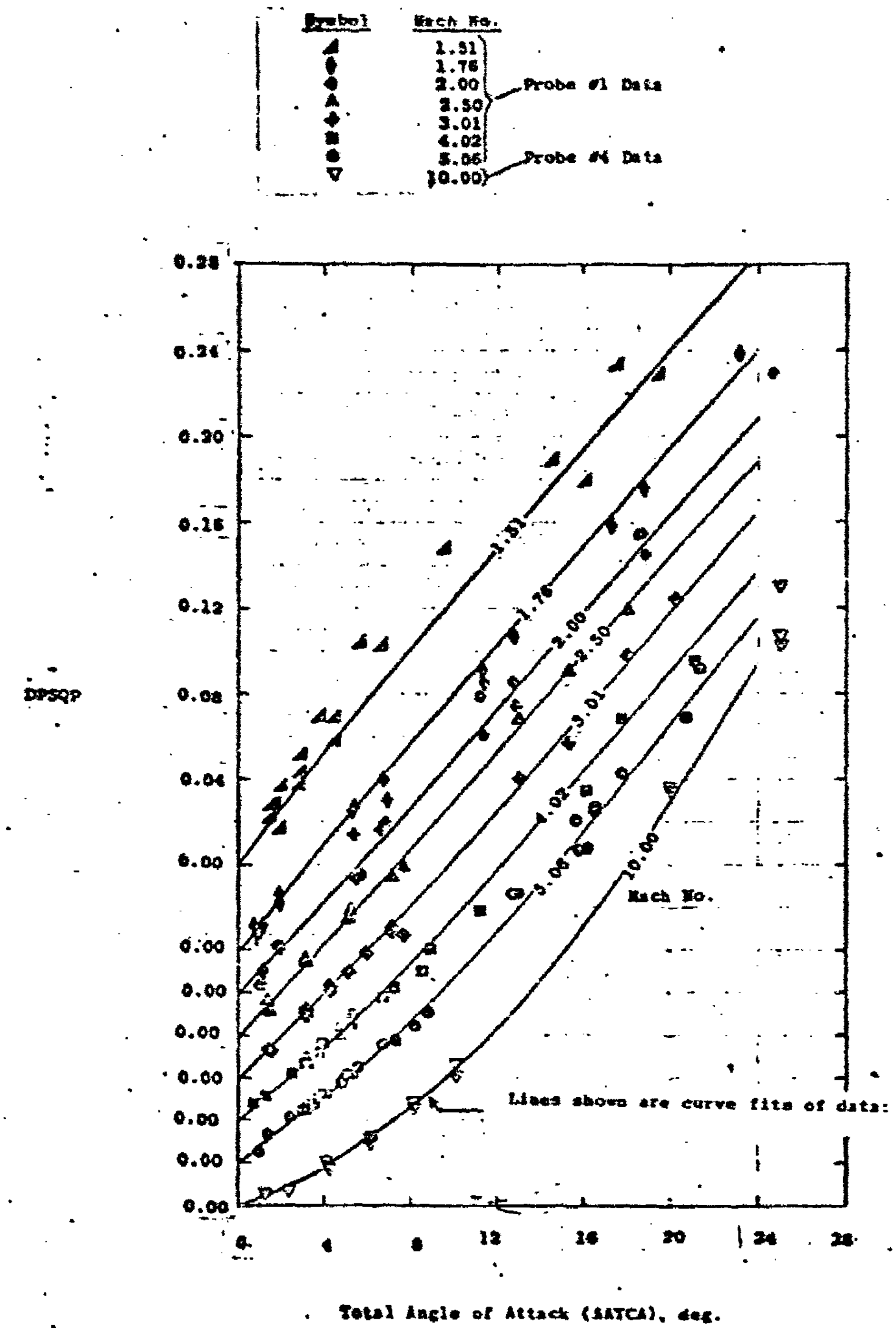


FIGURE A-7. TYPICAL PREDICTION PROGRAM RESULTS (MODEL PRESSURE)



a. MACH NUMBER

FIGURE A-8. MACH/FLOW ANGULARITY PROBE CALIBRATION DATA AND CURVE FITS



B. TOTAL ANGLE OF ATTACK

FIGURE A-8. MACH/FLOW ANGULARITY PROBE CALIBRATION DATA AND CURVE FITS (CONT'D)

Not all existing calibration data for Probe #1 are included on Figure A-8a. A distinct difference in the shape of the PAVGP5 vs. DPSQP curves was noted between the two probes, therefore all data for total angle of attack greater than 7 degrees (corresponds to DPSQP $\geq$ 0.7) was omitted for Probe No. 1, with the exception of data at Mach No. 1.5. This omission forced the curve fit to agree with Probe No. 4 calibration data. The resulting curve fits used to reduce the data are considered to be the best possible based on the available calibration data, but these could be significantly improved with additional calibration data for the same probe (No. 4).

Local total temperature was computed from the shielded thermocouple measured value (TOSM) using the method of Varner, Reference 16. In this method, the analysis is based on the total temperature variation in a laminar developing flow within a tube whose walls are at the adiabatic recovery temperature of the local flow field. This approach results in the ability to theoretically correct probe data for all local flow field conditions (a wide range of Reynolds numbers) using a limited amount of calibration data acquired in the tunnel freestream. To correct the measured temperature, the following parameters must be defined experimentally: local Mach number and Pitot pressure in front of the probe, the effective vent area ratio (AV/AE) and the local Mach number of the flow entering the probe (ME). For this test, the local corrected total temperatures were evaluated at the Mach/Flow-Angularity probe positions (TOSC values) and at the Pitot tube positions (TOSCP values) by an interpolation scheme. The approach used was to define, by linear interpolation, the local measured total temperature at the probe height and then to correct the interpolated value using the probe defined Mach number (MLC or MP) and the measured Pitot pressure (either P5 or PP). The nearest wall temperature measurement (TWJ) was included in the interpolation to define a value of uncorrected temperature at zero height. The effective vent area ratio, AV/AE was determined from freestream calibration data to be time dependent, decreasing in value as the test progressed, indicating that the tube vent holes were decreasing in size. The value used in the data reduction was:

$$AV/AE = 0.153 - 0.0005\ (SURVEY) \tag{A-9}$$

The entrance Mach number was defined in terms of the vent area ratio by an approximate equation:

$$ME = 0.578(AV/AE) \tag{A-10}$$

which assumes that the flow is sonic at the vent area and AV/AE is less than 0.5. Shielded thermocouple data reduction equations are given in detail in Reference 4.

Ideal compressible gas relationships were used in the calculation of local static temperature and pressure values and in evaluating the local Mach number at the Pitot tube. The equations for air (ratio of specific heats = 1.4), are listed below:

$$\frac{T}{Tt} = \left(1 + \frac{M^2}{5}\right)^{-1} \tag{A-11}$$

$$\frac{P}{P_t} = \left(1 + \frac{M^2}{5}\right)^{-7/2}, \text{ for } M \leq 1 \tag{A-12}$$

$$\frac{P_{t_2}}{P_1} = \left\{\frac{6M_1{}^2}{5}\right\}^{7/2}\left\{\frac{6}{7M_1{}^2-1}\right\}^{5/2}, \text{ for } M_1 > 1 \tag{A-13}$$

The first step in using the above equations was to compute the static pressure at the Mach/Flow-Angularity probe heights. To make these calculations, the following substitutions were made in Equations (A-12) and (A-13): $P_t \sim P5$, $P_{t_2} \sim P5$, $M \sim MLC$, $M_1 \sim MLC$. Static pressure at the Pitot probe (PSP) was defined by linear interpolation of the inferred static pressure based on the Mach/Flow-Angularity probe results and the model wall orifice pressure used to define the static pressure at zero height. The Mach number determined from the Pitot tube (MP) was then defined from Equations (A-12) and (A-13) with the substitutions: $p \sim PSP$, $P_1 \sim PSP$, $P_{t_2} \sim PP$.

The local static temperatures were computed using the appropriate local Mach number for Equation (A-11).

Local velocities were calculated from

$$VL = 49.0223\ M\sqrt{T},\ \text{ft/sec} \tag{A-14}$$

where M and T (^{o}R) are the appropriate local values of Mach number and static temperature.

Velocity vectors with respect to the Mach/Flow-Angularity probe axis system were computed according to the definitions given in Figure A-9. These values were transformed to the tunnel axis system (Figure A-10) by rotation of the axes through pitch, yaw and roll angle sequence corresponding to the probe misalignment angles defined as THETAO, PSIO and PHIO. Misalignment values in yaw and roll were determined from the freestream calibration that was obtained at the beginning of each test shift. The pitch misalignment was evaluated for each survey by determining what value of THETAO would best null the pressure differential DP13 on the probe , i.e., THETAO value for DP13 = 0.0.

The freestream velocity vectors were transformed to the model axis system by rotation of the axes through pitch and roll respectively, corresponding to the model pitch angle (ALPHA-MODEL) and the model roll angle (ROLL-MODEL). Velocity vector definitions in the model axis system are noted in Figure A-11.

The quantity of tabular and graphical data involved in the shock layer surveys is rather lengthy, involving several volumes of reports for this test series. An example of the Pitot and total temperature data tabulations is shown in Table A-3 (11 pages). Included in this table (on Page 3) are the Preston tube data results defining the wall shear and skin friction coefficient. A representative set of graphs for these data are shown in Figures A-12 through A-15. Figures A-12 and A-13 depict the uncorrected and

Notes:

1. All vectors are shown in positive directions.
2. PHI is computed directly from the pressures
3. Local Mach number (MLC) and the total angle of attack (AATCA) are computed from curve fits
4. Velocity vector components:

$$\frac{UP}{VL} = \cos(AATCA)$$

$$\frac{VP}{VL} = \sin(AATCA) \cdot \sin(PHI)$$

$$\frac{WP}{VL} = \sin(AATCA) \cdot \cos(PHI)$$

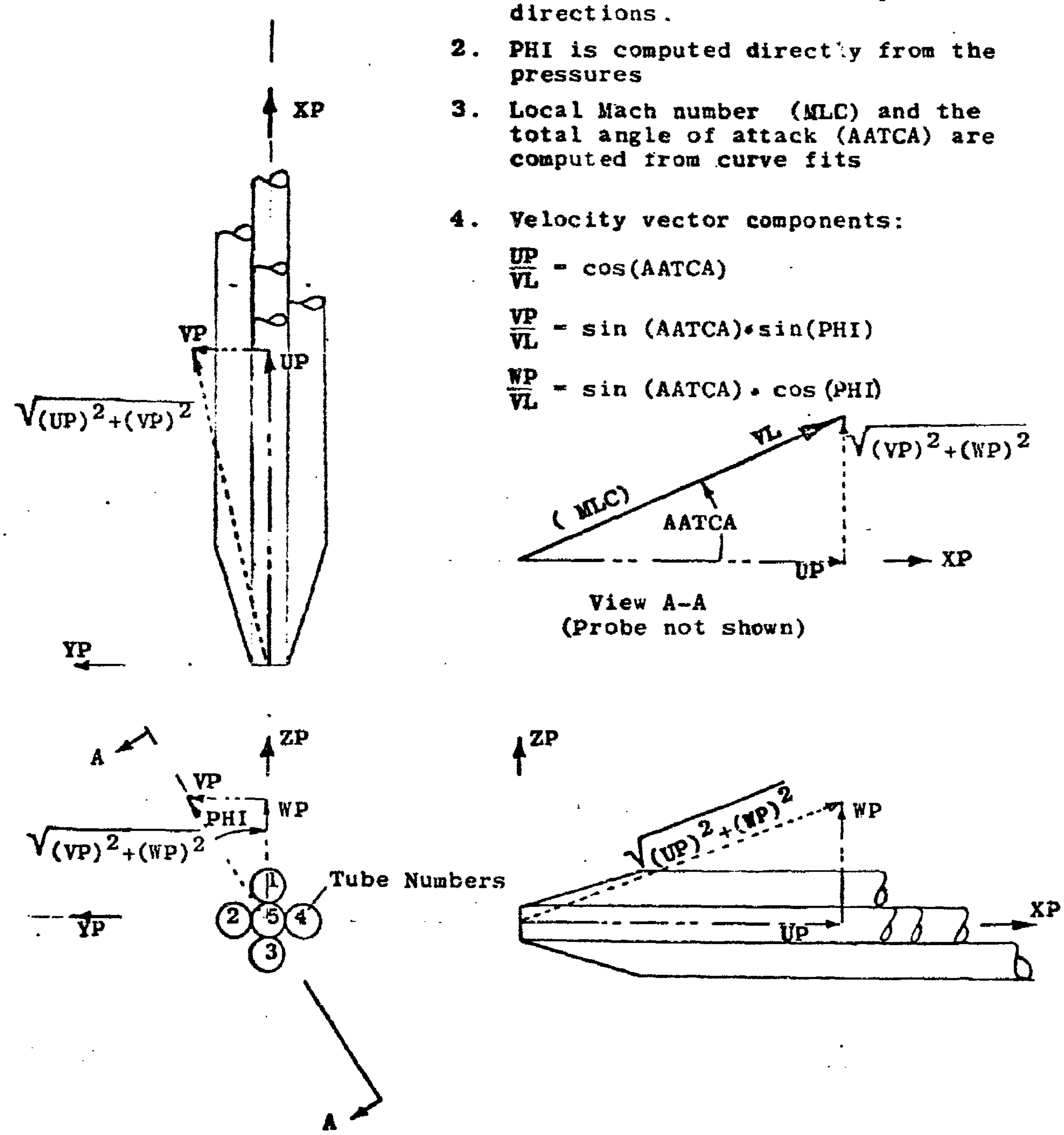


FIGURE A-9. VELOCITY VECTOR DEFINITION WITH RESPECT TO THE PROBE AXIS SYSTEM

NOTES:

1. Positive directions of velocity vectors and probe misalignments are shown.

2. See Fig. A-9 for definition of velocity vector components in the probe axis system (i.e., UP/VL, VP/VL, WP/VL).

3. Velocity vector components:

$$\frac{UT}{VL} = \frac{UP}{VL}\,(A1) + \frac{VP}{VL}\,(A2) + \frac{WP}{VL}\,(A3)$$

$$\frac{VT}{VL} = \frac{UP}{VL}\,(B1) + \frac{VP}{VL}\,(B2) + \frac{WP}{VL}\,(B3)$$

$$\frac{WT}{VL} = \frac{UP}{VL}\,(C1) + \frac{VP}{VL}\,(C2) + \frac{WP}{VL}\,(C3)$$

Where $\begin{Bmatrix} A1, A2, A3 \\ B1, B2, B3 \\ C1, C2, C3 \end{Bmatrix}$ are axis rotation coefficients:

A1 = cos(THETAO).cos(PSIO)

A2 = -cos(THETAO).sin(PSIO).cos(PHIO)
+sin(THETAO).sin(PHIO)

A3 = cos(THETAO).sin(PSIO).sin(PHIO)
+sin(THETAO).cos(PHIO)

B1 = sin(PSIO)

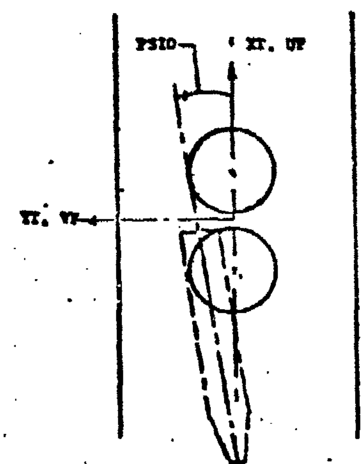
B2 = cos(PSIO).cos(PHIO)

B3 = -cos(PSIO).sin(PHIO)

C1 = -sin(THETAO).cos(PSIO)

C2 = sin(THETAO).sin(PSIO).cos(PHIO)
+cos(THETAO).sin(PHIO)

C3 = -sin(THETAO).sin(PSIO).sin(PHIO)
+cos(THETAO).cos(PHIO)



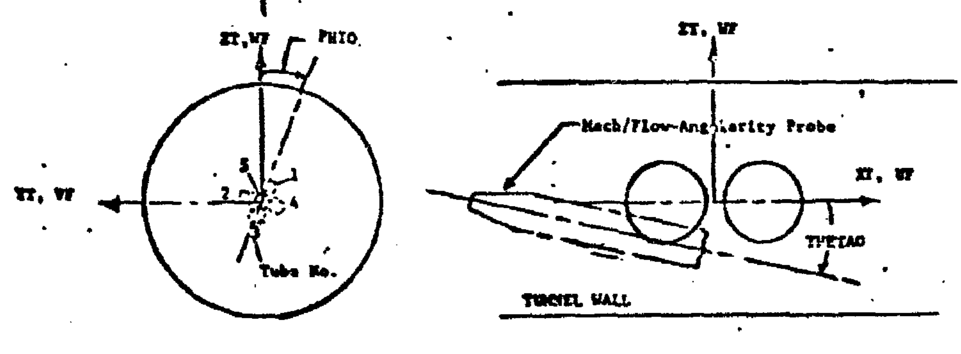


FIGURE A-10. VELOCITY VECTOR DEFINITION WITH RESPECT TO THE TUNNEL AXIS SYSTEM

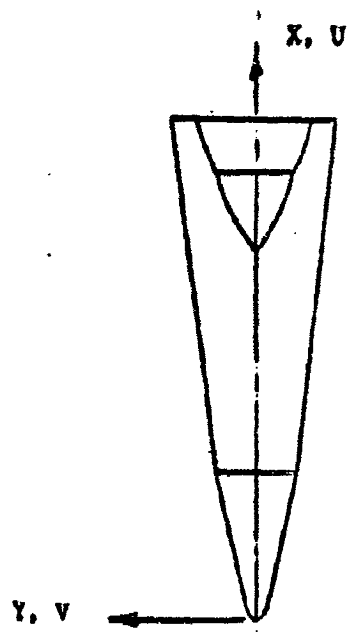
NOTES:

1. Positive direction of velocity vectors are shown.
2. See Fig. A-10 for definitions of velocity vector components in the tunnel axis system. (i.e. UF/VL, VF/VL, WF/VL)
3. Velocity vector components:

$$\frac{U}{VL} = \left(\frac{UF}{VL}\right) \cdot \cos(\text{ALPHA-MODEL}) - \left(\frac{WF}{VL}\right) \cdot \sin(\text{ALPHA-MODEL})$$

$$\frac{V}{VL} = \left(\frac{UF}{VL}\right)\left(-\sin(\text{ROLL-MODEL}) \cdot \sin(\text{ALPHA-MODEL})\right) + \left(\frac{VF}{VL}\right) \cdot \cos(\text{ROLL-MODEL}) + \left(\frac{WF}{VL}\right)\left(-\sin(\text{ROLL-MODEL}) \cdot \cos(\text{ALPHA-MODEL})\right)$$

$$\frac{W}{VL} = \left(\frac{UF}{VL}\right)\left(\cos(\text{ROLL-MODEL}) \cdot \sin(\text{ALPHA-MODEL})\right) + \left(\frac{VF}{VL}\right) \cdot \sin(\text{ROLL-MODEL}) + \left(\frac{WF}{VL}\right)\left(\cos(\text{ROLL-MODEL}) \cdot \cos(\text{ALPHA-MODEL})\right)$$



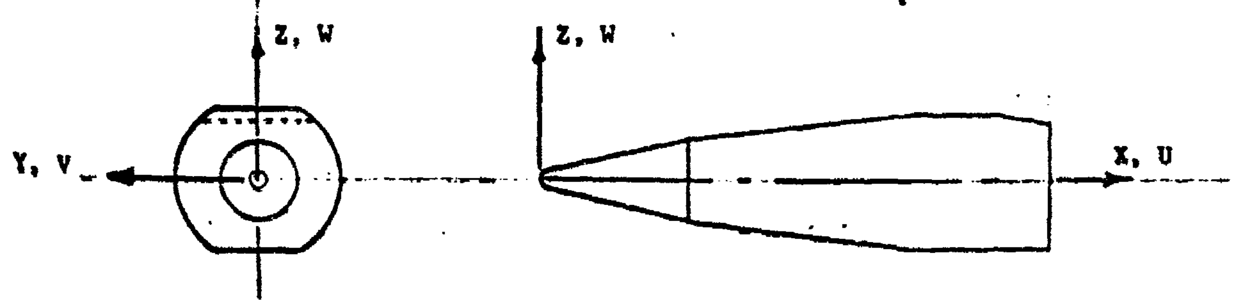
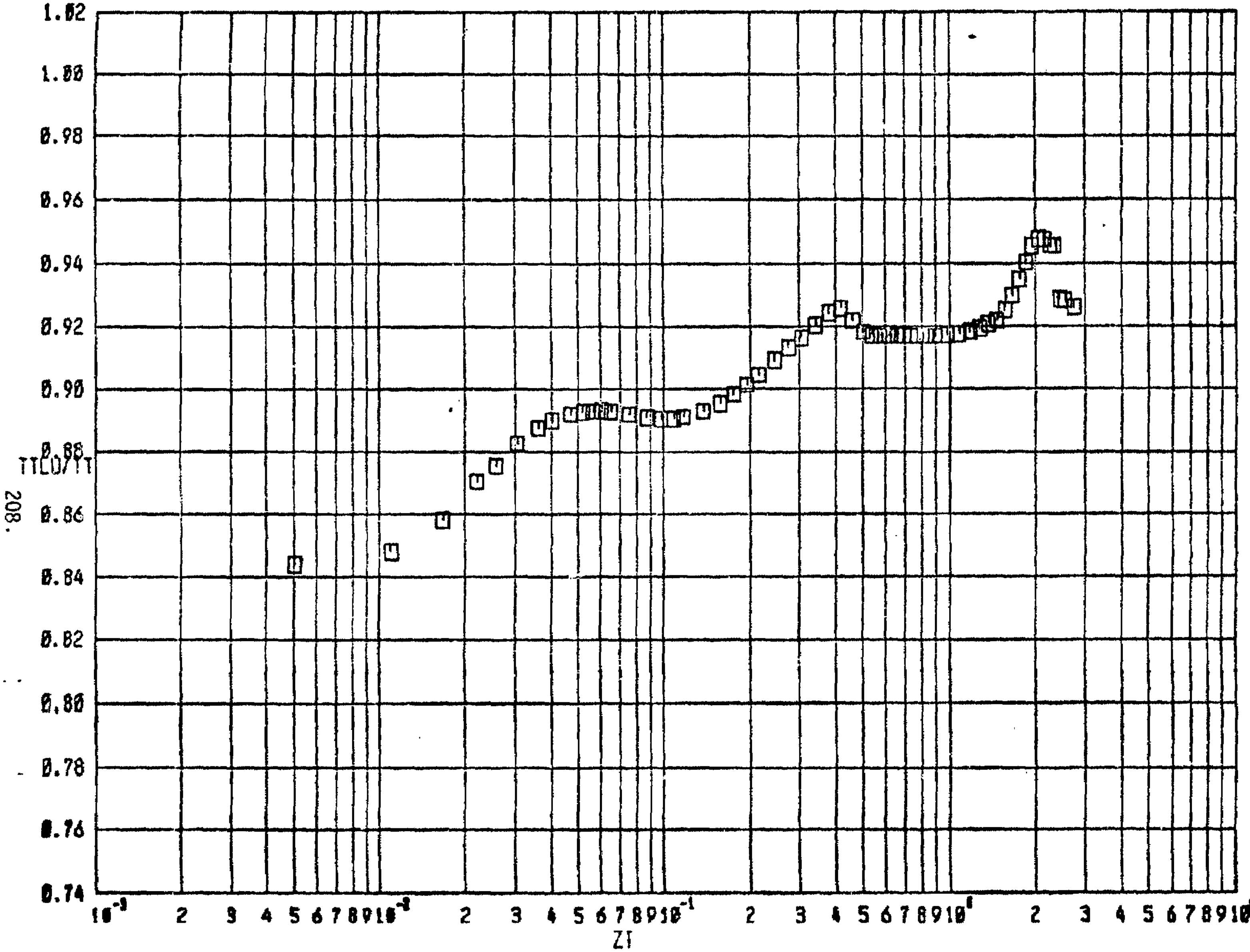


FIGURE A-11. VELOCITY VECTOR DEFINITION WITH RESPECT TO THE MODEL AXIS SYSTEM

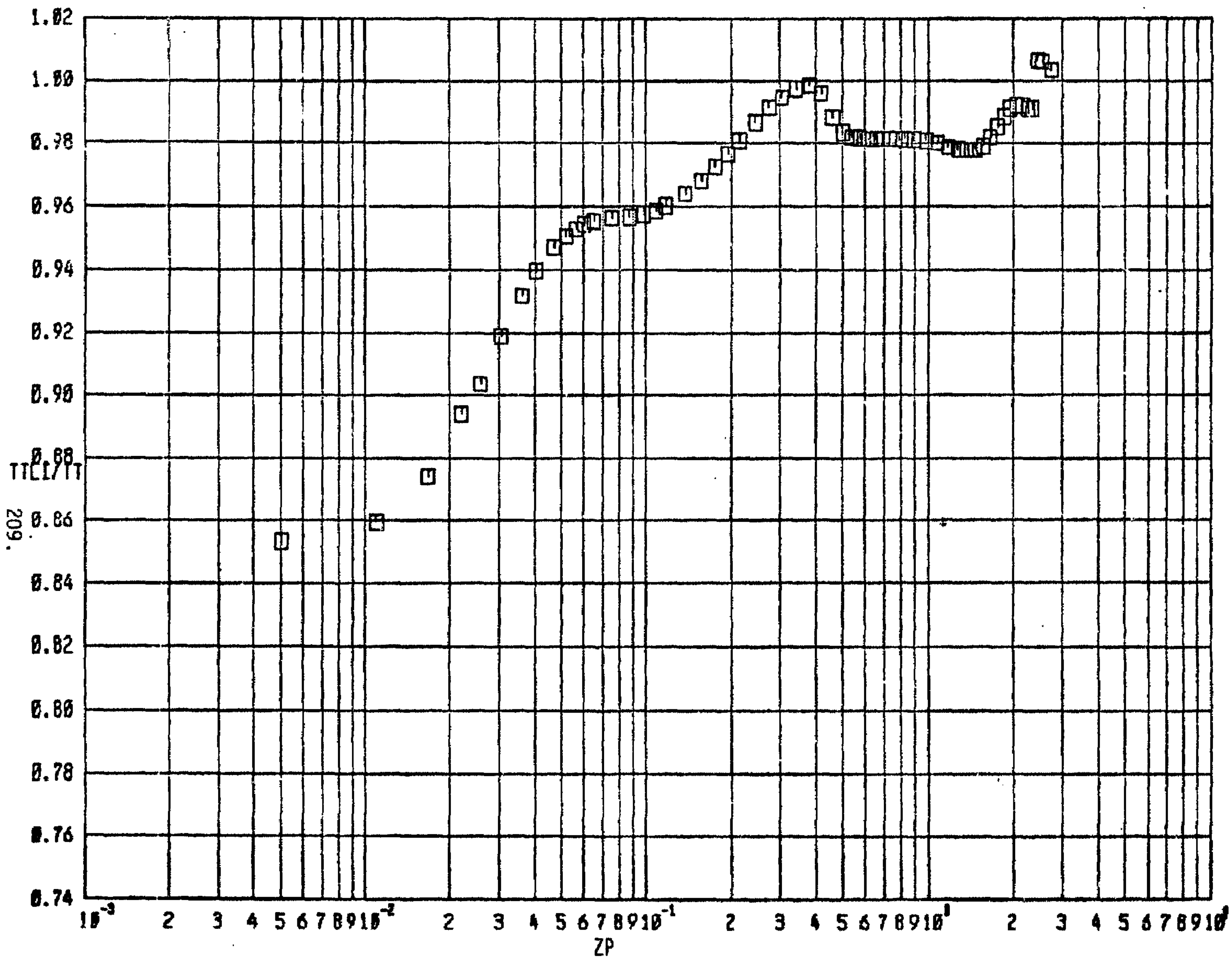


RUN 054

FIGURE A-12. SHOCK LAYER UNCORRECTED TOTAL TEMPERATURE DATA

BMO/SAI MAT PHASE I

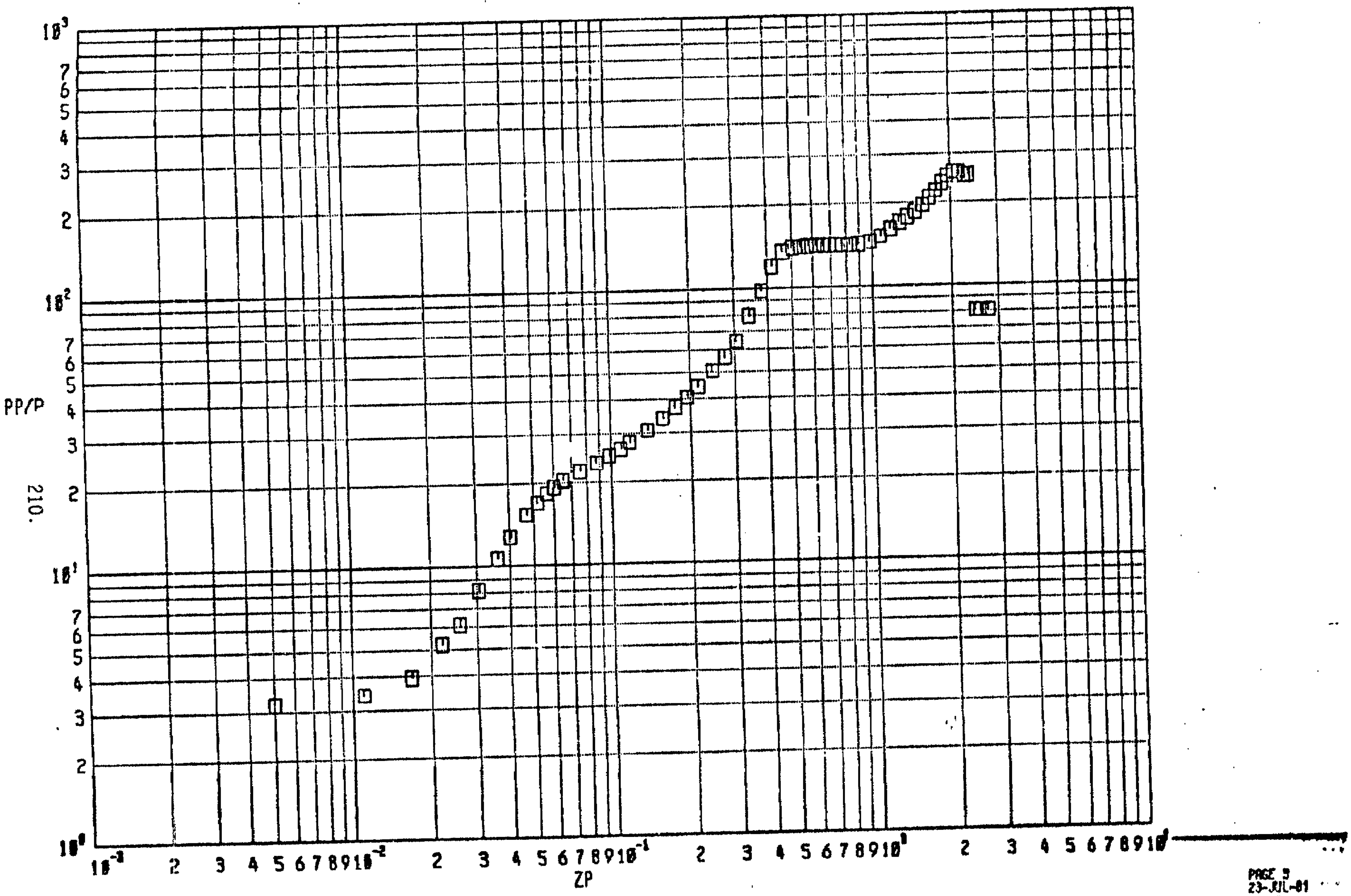
PAGE 1
23-JUL-81
14:28



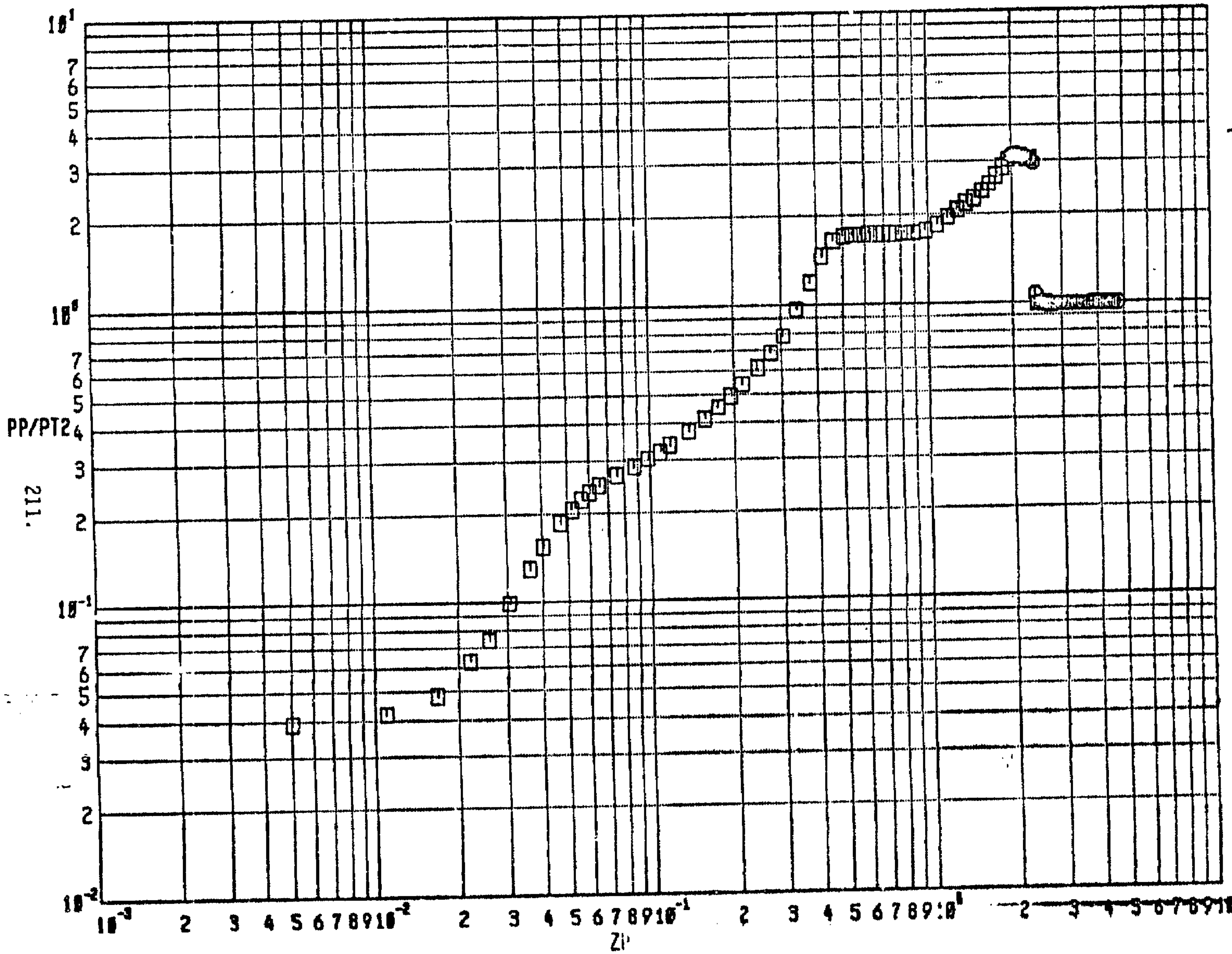
RUN 054 FIGURE A-13. SHOCK LAYER CORRECTED TOTAL TEMPERATURE DATA

BMO/SAI MAT PHASE I

PAGE 2
23-JUL-81
14:37



RUN 054 FIGURE A-14. SHOCK LAYER PITOT PRESSURE DATA BMO/SAI MAT PHASE I



RUN 054 054 FIGURE A-15. SHOCK LAYER PITOT PRESSURE DATA BMO/SAI MAT PHASE I

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
BMO/SAI MAT PHASE I

TABLE A-3. SHOCK LAYER DATA

DATE COMPUTED 22-JUL-81
TIME COMPUTED 06:23:18
DATE RECORDED 24-APR-81
TIME RECORDED 5:51:22
PROJECT NUMBER C145VB

PAGE 1

RUN 54 ALPHA SECTOR= 1.99 DEG
M = 7.97 ALPHAP = -10.01 DEG
RE = 3.623E+06 MODEL-ROLL = 180.00 DEG

CONFIGURATION 10.5/7-DEG BICONIC/S8+DS
NOSE RADIUS,IN 0.5000
TRIP .06 MACHINED
FLAP NONE

DATA TYPE : 3,SURVEY - PP AND TT   SURVEY STATION NO = 58   PWX/PT= 0.250E-03   ALPT= -2.99 DEG

TEST CONDITIONS AND LOCAL CONDITIONS AT THE PITOT PROBE

POINT	PT (PSIA)	TT (DEGR)	P (PSIA)	PT2 (PSIA)	ZP (IN)	PP (PSIA)	PP/PT2	PP/P	PP/PWX	TTLI/TT	ML	ZPU (IN)	PPU (PSIA)	PPU/PT2
1	834.52	1355.4	0.087	7.190	0.0050	0.280	0.0390	3.21	1.34	0.85	0.66	2.0050	22.3360	3.1067
2	834.62	1355.4	0.087	7.191	0.0110	0.301	0.0418	3.44	1.44	0.86	0.74	2.0110	22.3606	3.1097
3	834.72	1355.4	0.087	7.191	0.0168	0.346	0.0481	3.96	1.66	0.87	0.88	2.0168	22.3880	3.1132
4	834.56	1355.3	0.087	7.190	0.0220	0.454	0.0632	5.20	2.18	0.89	1.12	2.0220	22.4099	3.1168
5	834.47	1355.3	0.087	7.189	0.0258	0.535	0.0745	6.13	2.57	0.90	1.25	2.0258	22.4214	3.1189
6	834.47	1355.2	0.087	7.189	0.0306	0.712	0.0990	8.15	3.42	0.92	1.50	2.0306	22.4427	3.1217
7	834.56	1355.1	0.087	7.190	0.0362	0.930	0.1294	10.65	4.46	0.93	1.75	2.0362	22.4828	3.1269
8	834.49	1355.2	0.087	7.189	0.0406	1.111	0.1545	12.72	5.33	0.94	1.94	2.0406	22.5062	3.1307
9	834.51	1355.2	0.087	7.190	0.0470	1.339	0.1863	15.33	6.43	0.95	2.15	2.0470	22.5502	3.1365
10	834.56	1355.0	0.087	7.190	0.0518	1.483	0.2063	16.98	7.12	0.95	2.27	2.0518	22.5862	3.1413
11	834.41	1354.9	0.087	7.189	0.0565	1.599	0.2225	18.31	7.68	0.95	2.36	2.0565	22.6126	3.1455
12	834.45	1355.0	0.087	7.189	0.0602	1.686	0.2346	19.31	8.09	0.95	2.43	2.0602	22.6402	3.1492
13	834.34	1354.9	0.087	7.188	0.0654	1.781	0.2478	20.40	8.55	0.96	2.50	2.0654	22.6708	3.1539
14	834.58	1354.8	0.087	7.190	0.0654	1.785	0.2482	20.44	8.57	0.96	2.50	2.0654	22.6821	3.1546
15	834.56	1354.7	0.087	7.190	0.0754	1.924	0.2675	22.02	9.23	0.96	2.60	2.0754	22.7212	3.1601
16	834.67	1354.7	0.087	7.191	0.0873	2.058	0.2861	23.56	9.87	0.96	2.70	2.0873	22.7203	3.1596
17	834.62	1354.7	0.087	7.191	0.0871	2.057	0.2861	23.55	9.87	0.96	2.70	2.0871	22.7168	3.1592
18	834.62	1354.6	0.087	7.191	0.0980	2.182	0.3034	24.98	10.47	0.96	2.78	2.0980	22.6550	3.1506
19	834.51	1354.6	0.087	7.190	0.1088	2.302	0.3202	26.36	11.05	0.96	2.86	2.1088	22.5767	3.1401
20	834.45	1354.5	0.087	7.189	0.1180	2.427	0.3376	27.79	11.65	0.96	2.94	2.1180	22.5182	3.1322
21	834.54	1354.4	0.087	7.190	0.1377	2.689	0.3740	30.79	12.91	0.96	3.11	2 .377	22.4940	3.1285
22	834.48	1354.4	0.087	7.189	0.1578	2.968	0.4128	33.98	14.24	0.97	3.27	2.1578	22.5484	3.1364
23	834.45	1354.5	0.087	7.189	0.1764	3.251	0.4522	37.23	15.60	0.97	3.43	2.1764	22.5713	3.1396
24	834.65	1354.4	0.087	7.191	0.1958	3.536	0.4917	40.48	16.97	0.98	3.58	2.1958	22.4886	3.1274
25	834.61	1354.4	0.087	7.191	0.2153	3.873	0.5386	44.34	18.58	0.98	3.75	2.2153	22.2562	3.0952
26	834.67	1354.3	0.087	7.191	0.2449	4.398	0.6117	50.35	21.10	0.99	4.00	2.2449	21.9860	3.0574
27	834.67	1354.4	0.087	7.191	0.2746	4.947	0.6880	56.63	23.74	0.99	4.25	2.2746	22.0327	3.0639
28	834.85	1354.4	0.087	7.192	0.3032	5.635	0.7834	64.49	27.03	0.99	4.54	2.3032	22.0943	3.0719
29	834.87	1354.3	0.087	7.193	0.3422	6.963	0.9681	79.70	33.40	1.00	5.06	2.3422	22.0659	3.0678

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
BMO/SAI MAT PHASE I

TABLE A-3. SHOCK LAYER DATA (CONT.D)

DATE COMPUTED 22-JUL-81
TIME COMPUTED 06:23:16
DATE RECORDED 24-APR-81
TIME RECORDED 5:51:22
PROJECT NUMBER C145VB

PAGE 2

RUN 54	ALPHA SECTOR= 1.99 DEG	CONFIGURATION	NOSE RADIUS,IN	TRIP	FLAP
M = 7.97	ALPHAP = -10.01 DEG	10.5/7-DEG BICONIC/SS+DS	0.5000	.06 MACHINED	NONE
RE = 1.623E+06	MODEL-ROLL = 180.00 DEG				

DATA TYPE : 3,SURVEY - PP AND TT   SURVEY STATION NO = 58   PWX/PT= 0.250E-03   ALPT= -2.99 DEG

TEST CONDITIONS AND LOCAL CONDITIONS AT THE PITOT PROBE

POINT	PT (PSIA)	TT (DEGR)	P (PSIA)	PT2 (PSIA)	ZP (IN)	PP (PSIA)	PP/PT2	PP/P	PP/PWX	TTLI/TT	ML	ZPU (IN)	PPU (PSIA)	PPU/PT2
30	834.83	1354.2	0.087	7.192	0.3814	8.554	1.1893	97.90	41.03	1.00	5.61	2.3814	21.3340	2.9662
31	834.76	1354.3	0.087	7.192	0.4197	10.484	1.4578	120.01	50.30	1.00	6.22	2.4197	7.6203	1.0596
32	834.85	1354.3	0.087	7.192	0.4601	11.815	1.6427	135.23	56.68	0.99	6.61	2.4601	7.1471	0.9937
33	834.68	1354.2	0.087	7.191	0.4985	12.204	1.6971	139.71	58.55	0.98	6.71	2.4985	7.1418	0.9932
34	834.80	1354.1	0.087	7.192	0.5381	12.297	1.7098	140.75	58.99	0.98	6.74	2.5381	7.1402	0.9928
35	834.87	1354.2	0.087	7.193	0.5755	12.346	1.7165	141.30	59.22	0.98	6.75	2.5755	7.1389	0.9925
36	834.89	1354.2	0.087	7.193	0.6151	12.393	1.7229	141.83	59.44	0.98	6.77	2.6151	7.1361	0.9921
37	834.85	1354.1	0.087	7.192	0.6546	12.415	1.7261	142.09	59.55	0.98	6.77	2.6546	7.1337	0.9918
38	834.78	1354.2	0.087	7.192	0.6942	12.402	1.7244	141.96	59.50	0.98	6.77	2.6942	7.1287	0.9912
39	834.80	1354.3	0.087	7.192	0.7329	12.387	1.7223	141.78	59.42	0.98	6.76	2.7329	7.1272	0.9910
40	834.87	1354.3	0.087	7.193	0.7716	12.391	1.7228	141.82	59.44	0.98	6.77	2.7716	7.1246	0.9905
41	834.75	1354.1	0.087	7.192	0.8306	12.433	1.7289	142.32	59.65	0.98	6.78	2.8306	7.1205	0.9901
42	834.92	1354.2	0.087	7.193	0.8896	12.482	1.7353	142.85	59.87	0.98	6.79	2.8896	7.1231	0.9903
43	834.92	1354.2	0.087	7.193	0.9861	12.670	1.7615	145.01	60.77	0.98	6.84	2.9861	7.1189	0.9897
44	834.89	1354.1	0.087	7.193	1.0855	13.247	1.8416	151.61	63.54	0.98	7.00	3.0855	7.1182	0.9896
45	834.77	1354.2	0.087	7.192	1.1817	14.091	1.9593	161.30	67.60	0.98	7.22	3.1817	7.1170	0.9896
46	834.79	1354.2	0.087	7.192	1.2787	14.888	2.0701	170.41	71.42	0.98	7.42	3.2787	7.1157	0.9894
47	834.65	1354.2	0.087	7.191	1.3756	15.584	2.1671	178.40	74.77	0.98	7.60	3.3756	7.1127	0.9891
48	834.54	1354.2	0.087	7.190	1.4740	16.164	2.2482	185.07	77.57	0.98	7.74	3.4740	7.1115	0.9891
49	834.67	1354.2	0.087	7.191	1.5706	17.100	2.3780	195.76	82.05	0.98	7.96	3.5706	7.1117	0.9890
50	834.71	1354.3	0.087	7.191	1.6698	18.164	2.5259	207.94	87.15	0.98	8.20	3.6698	7.1174	0.9897
51	834.76	1354.3	0.087	7.192	1.7667	19.227	2.6735	220.08	92.24	0.99	8.44	3.7667	7.1211	0.9902
52	834.81	1354.1	0.087	7.192	1.8635	20.529	2.8543	234.97	98.48	0.99	8.72	3.8635	7.1285	0.9911
53	834.84	1354.2	0.087	7.192	1.9616	21.805	3.0317	249.57	104.60	0.99	8.99	3.9616	7.1359	0.9921
54	834.69	1354.2	0.087	7.191	2.0602	22.530	3.1330	257.91	108.10	0.99	9.14	4.0602	7.1388	0.9927
55	834.81	1354.1	0.087	7.192	2.1559	22.463	3.1233	257.11	107.76	0.99	9.13	4.1559	7.1428	0.9931
56	834.77	1354.2	0.087	7.192	2.2551	21.904	3.0457	250.72	105.08	0.99	9.01	4.2551	7.1426	0.9932
57	834.83	1354.2	0.087	7.192	2.3503	21.934	3.0496	251.05	105.22	0.99	9.02	4.3503	7.1426	0.9931
58	834.79	1354.2	0.087	7.192	2.4491	7.094	0.9864	81.20	34.03	1.01	5.10	4.4491	7.1427	0.9931

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
BMO/SAI MAT PHASE I

TABLE A-3. SHOCK LAYER DATA (CONT'D)

DATE COMPUTED 22-JUL-81
TIME COMPUTED 06:23:23
DATE RECORDED 24-APR-81
TIME RECORDED 5:51:22
PROJECT NUMBER C145VB

PAGE 4
RUN 54 ALPHA SECTOR= 1.99 DEG
M = 7.97 ALPHAP = -10.01 DEG
RE = 3.623E+06 MODEL-ROLL = 180.00 DEG

CONFIGURATION 10.5/7-DEG BICONIC/SS+DS
NOSE RADIUS,IN 0.5000
TRIP .06 MACHINED
FLAP NONE

DATA TYPE : 3,SURVEY - PP AND TT SURVEY STATION NO = 58 PWX/PT= 0.250E-03 ALPT= -2.99 DEG

LOCAL CONDITIONS AT THE TOTAL TEMPERATURE PROBE

POINT	ZT (IN)	PPI (PSIA)	PPI/PWX	TTLU (DEGR)	TTLU/TT	ML	RETD	ETA	TTL (DEGR)	TTL/TT	TWX (DEGR)	TIME HR:MIN:SEC
1	0.005	0.280	1.34	1143.8	0.844	0.66	1.104E+01	0.8634	1156.6	0.853	1082.	5: 51:22
2	0.011	0.301	1.44	1149.3	0.848	0.74	1.239E+01	0.8643	1165.0	0.860	1082.	5: 51:36
3	0.017	0.346	1.66	1163.1	0.858	0.88	1.471E+01	0.8657	1184.6	0.874	1082.	5: 51:52
4	0.022	0.454	2.18	1179.5	0.870	1.12	1.887E+01	0.8681	1211.4	0.894	1082.	5: 52: 8
5	0.026	0.535	2.57	1186.4	0.875	1.25	2.140E+01	0.8694	1224.5	0.904	1082.	5: 52:20
6	0.031	0.712	3.42	1195.8	0.882	1.50	2.642E+01	0.8718	1245.3	0.919	1082.	5: 52:36
7	0.036	0.930	4.46	1202.5	0.887	1.75	3.208E+01	0.8742	1262.9	0.932	1082.	5: 52:50
8	0.041	1.111	5.33	1205.9	0.890	1.94	3.657E+01	0.8759	1273.6	0.940	1081.	5: 53: 4
9	0.047	1.339	6.43	1208.4	0.892	2.15	4.209E+01	0.8780	1283.5	0.947	1081.	5: 53:17
10	0.052	1.483	7.12	1209.3	0.893	2.27	4.552E+01	0.8792	1288.3	0.951	1081.	5: 53:30
11	0.056	1.599	7.68	1209.7	0.893	2.36	4.829E+01	0.8801	1291.4	0.953	1081.	5: 53:43
12	0.060	1.686	8.09	1209.8	0.893	2.43	5.034E+01	0.8808	1293.3	0.954	1081.	5: 53:58
13	0.065	1.781	8.55	1209.3	0.893	2.50	5.260E+01	0.8815	1294.6	0.956	1081.	5: 54:15
14	0.065	1.780	8.54	1209.3	0.893	2.50	5.257E+01	0.8815	1294.6	0.956	1081.	5: 54:35
15	0.075	1.924	9.23	1208.1	0.892	2.60	5.599E+01	0.8825	1295.8	0.956	1081.	5: 54:54
16	0.087	2.058	9.87	1206.7	0.891	2.70	5.923E+01	0.8835	1296.2	0.957	1081.	5: 55:11
17	0.087	2.055	9.86	1206.7	0.891	2.70	5.917E+01	0.8835	1296.2	0.957	1081.	5: 55:41
18	0.098	2.182	10.47	1206.0	0.890	2.78	6.217E+01	0.8844	1297.1	0.958	1080.	5: 55:49
19	0.109	2.302	11.05	1206.0	0.890	2.86	6.498E+01	0.8852	1298.6	0.959	1080.	5: 55:57
20	0.118	2.427	11.65	1206.7	0.891	2.94	6.783E+01	0.8860	1300.7	0.960	1080.	5: 56: 4
21	0.138	2.689	12.91	1209.2	0.893	3.11	7.377E+01	0.8876	1305.8	0.964	1080.	5: 56:12
22	0.158	2.968	14.24	1212.5	0.895	3.27	7.996E+01	0.8893	1311.4	0.968	1080.	5: 56:20
23	0.176	3.251	15.60	1216.4	0.898	3.43	8.615E+01	0.8908	1317.2	0.972	1080.	5: 56:28
24	0.196	3.536	16.97	1220.4	0.901	3.58	9.233E+01	0.8923	1322.9	0.977	1080.	5: 56:54
25	0.215	3.873	18.58	1224.7	0.904	3.75	9.961E+01	0.8940	1328.5	0.981	1080.	5: 57: 2
26	0.245	4.398	21.10	1231.0	0.909	4.00	1.109E+02	0.8966	1336.3	0.987	1080.	5: 57:10
27	0.275	4.947	23.74	1236.6	0.913	4.25	1.227E+02	0.8991	1342.7	0.991	1080.	5: 57:19
28	0.303	5.635	27.03	1240.9	0.916	4.54	1.377E+02	0.9021	1347.0	0.995	1080.	5: 57:25
29	0.342	6.963	33.40	1246.2	0.920	5.06	1.670E+02	0.9076	1350.6	0.997	1080.	5: 57:32
30	0.381	8.554	41.03	1251.4	0.924	5.61	2.022E+02	0.9136	1352.3	0.999	1079.	5: 57:38

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
BMO/SAI MAT PHASE I

DATE COMPUTED 22-JUL-81
TIME COMPUTED 06:23:23
DATE RECORDED 24-APR-81
TIME RECORDED 5:51:22
PROJECT NUMBER C145V8

TABLE A-3. SHOCK LAYER DATA (CONT'D)

PAGE 5
RUN 54 ALPHA SECTOR= 1.99 DEG
M = 7.97 ALPHAP = -10.01 DEG
RE = 3.623E+06 MODEL-ROLL = 180.00 DEG

CONFIGURATION 10.5/7-DEG BICONIC/S8+DS NOSE RADIUS,IN 0.5000 TRIP .06 MACHINED FLAP NONE

DATA TYPE : 3,SURVEY - PP AND TT SURVEY STATION NO = 58 PWX/PT= 0.250E-03 ALPT= -2.99 DEG

LOCAL CONDITIONS AT THE TOTAL TEMPERATURE PROBE

POINT	ZT (IN)	PPI (PSIA)	PPI/PWX	TTLU (DEGR)	TTLU/TT	ML	RETD	ETA	TTL (DEGR)	TTL/TT	TWX (DEGR)	TIME HR:MIN:SEC
31	0.420	10.484	50.30	1253.5	0.926	6.22	2.460E+02	0.9203	1348.7	0.996	1079.	5: 57:45
32	0.460	11.815	56.68	1248.3	0.922	6.61	2.781E+02	0.9249	1338.5	0.988	1079.	5: 57:52
33	0.498	12.204	58.55	1243.4	0.918	6.71	2.885E+02	0.9263	1331.8	0.983	1079.	5: 57:59
34	0.538	12.297	58.99	1241.9	0.917	6.74	2.911E+02	0.9266	1329.8	0.982	1079.	5: 58: 5
35	0.576	12.346	59.22	1241.7	0.917	6.75	2.923E+02	0.9268	1329.4	0.982	1079.	5: 58:12
36	0.615	12.393	59.44	1241.7	0.917	6.77	2.933E+02	0.9270	1329.3	0.982	1078.	5: 58:19
37	0.655	12.415	59.55	1241.7	0.917	6.77	2.939E+02	0.9270	1329.2	0.982	1078.	5: 58:26
38	0.694	12.402	59.50	1241.7	0.917	6.77	2.936E+02	0.9270	1329.2	0.982	1078.	5: 58:32
39	0.733	12.387	59.42	1241.7	0.917	6.76	2.932E+02	0.9269	1329.2	0.981	1078.	5: 58:39
40	0.772	12.391	59.44	1241.6	0.917	6.77	2.934E+02	0.9270	1329.1	0.981	1078.	5: 58:46
41	0.831	12.433	59.65	1241.5	0.917	6.78	2.944E+02	0.9271	1328.9	0.981	1078.	5: 58:53
42	0.890	12.482	59.87	1241.5	0.917	6.79	2.955E+02	0.9272	1328.7	0.981	1078.	5: 59: 0
43	0.986	12.670	60.77	1241.8	0.917	6.84	2.998E+02	0.9278	1328.4	0.981	1078.	5: 59: 9
44	1.086	13.247	63.54	1242.4	0.917	7.00	3.132E+02	0.9296	1327.2	0.980	1078.	5: 59:17
45	1.182	14.091	67.60	1243.6	0.918	7.22	3.330E+02	0.9321	1325.7	0.979	1078.	5: 59:25
46	1.279	14.888	71.42	1244.8	0.919	7.42	3.514E+02	0.9344	1324.5	0.978	1078.	5: 59:34
47	1.376	15.584	74.77	1246.8	0.921	7.60	3.674E+02	0.9364	1324.3	0.978	1077.	5: 59:42
48	1.474	16.164	77.57	1248.3	0.922	7.74	3.807E+02	0.9379	1324.1	0.978	1077.	5: 59:51
49	1.571	17.100	82.05	1252.6	0.925	7.96	4.014E+02	0.9403	1325.9	0.979	1077.	5: 59:59
50	1.670	18.164	87.15	1259.1	0.930	8.20	4.242E+02	0.9429	1329.7	0.982	1077.	6: 0: 8
51	1.767	19.227	92.24	1266.2	0.935	8.44	4.465E+02	0.9454	1334.3	0.985	1077.	6: 0:16
52	1.863	20.529	98.48	1273.6	0.941	8.72	4.742E+02	0.9484	1338.4	0.988	1077.	6: 0:25
53	1.962	21.805	104.60	1280.6	0.946	8.99	5.013E+02	0.9512	1342.3	0.991	1077.	6: 0:33
54	2.060	22.530	108.10	1283.6	0.948	9.14	5.171E+02	0.9528	1343.4	0.992	1077.	6: 0:42
55	2.156	22.463	107.76	1283.2	0.948	9.13	5.157E+02	0.9527	1343.2	0.992	1077.	6: 0:50
56	2.255	21.904	105.08	1280.8	0.946	9.01	5.036E+02	0.9514	1342.2	0.991	1077.	6: 0:59
57	2.350	21.934	105.22	1280.8	0.946	9.02	5.042E+02	0.9515	1342.2	0.991	1077.	6: 1: 7
58	2.449	7.094	34.03	1257.6	0.929	5.10	1.687E+02	0.9078	1363.0	1.007	1077.	6: 1:16
59	2.548	7.088	34.00	1257.0	0.928	5.10	1.682E+02	0.9078	1362.4	1.006	1077.	6: 1:24
60	2.742	7.073	33.93	1253.9	0.926	5.10	1.683E+02	0.9078	1359.0	1.003	1077.	6: 1:35

RUN 54

PT =	834.52	PSIA	V =	3885.7	FT/SEC
TT =	1355.4	DEGR	Q =	3.887	PSIA
P =	0.0873	PSIA	T =	98.8	DEGR
RE =	3.623E+06	PER FT	PT2 =	7.19	PSIA
MU =	7.952E-08	LBF-SEC/FT2	RHO =	2.385E-03	LBM/FT3
DEW=	-52.	DEG F	C.R.=	24.06	IN

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
RMO/SAT MAT PHASE I

TABLE A-3. SHOCK LAYER DATA (CONT'D)

DATE COMPUTED 22-JUL-81
TIME COMPUTED 06:23:24
DATE RECORDED 24-APR-81
TIME RECORDED 5:51:22
PROJECT NUMBER C145VB

PAGE 6
RUN 54
M = 7.97
RE = 3.623E+06

ALPHA SECTOR= 1.99 DEG
ALPHAP = -10.01 DEG
MODEL-ROLL = 180.00 DEG

CONFIGURATION 10.5/7-DEG BICONIC/SS+DS

NOSE RADIUS,IN 0.5000

TRIP .06 MACHINED

FLAP NONE

DATA TYPE : 3, SURVEY-PP AND TT
PRESSURE STABILIZATION STATISTICS

KNPP= 0.100
APP = 0.100

KNPPU= 1.000
APPU = 0.030

POINT	TIME HR:MIN:SEC	PP (PSIA)	PP1/PPF	PP/PPF	KPP	TNPP (SEC)	PPU (PSIA)	PPU1/ PPUF	PPU/ PPUF	KPPU	TNPPU (SEC)	TREC (SEC)	TDEL (SEC)
1	5: 51:22	0.280	1.0308	0.8990	0.150	13.83	22.336	1.0000	0.9999	-0.001	0.02	3.9	2.0
2	5: 51:36	0.301	1.0030	0.9993	-0.184	14.24	22.361	1.0007	1.0002	0.003	0.02	3.9	2.0
3	5: 51:52	0.346	0.9807	1.0580	-0.016	13.27	22.388	1.0000	1.0001	-0.002	0.02	3.9	2.0
4	5: 52: 8	0.454	0.9529	1.0983	0.055	10.79	22.410	1.0008	1.0005	-0.012	0.02	3.9	2.0
5	5: 52:20	0.535	0.9525	1.0876	0.110	9.22	22.421	1.0000	0.9998	0.006	0.02	3.9	2.0
6	5: 52:36	0.712	0.9606	1.0508	0.093	6.87	22.443	0.9999	0.9996	-0.010	0.02	3.9	2.0
7	5: 52:50	0.930	0.9599	1.0371	0.112	5.28	22.483	1.0003	0.9999	0.018	0.02	3.9	2.0
8	5: 53: 4	1.111	0.9808	1.0133	0.072	4.36	22.508	0.9995	0.9998	0.002	0.02	3.9	2.0
9	5: 53:17	1.339	0.9725	1.0150	0.120	3.65	22.550	1.0003	0.9998	0.003	0.02	3.9	2.0
10	5: 53:30	1.483	0.9907	1.0041	0.124	3.27	22.586	1.0001	1.0001	0.001	0.02	3.9	2.0
11	5: 53:43	1.599	0.9925	1.0029	0.076	3.04	22.613	1.0004	1.0002	-0.002	0.02	3.9	2.0
12	5: 53:58	1.686	0.9968	1.0006	-0.028	2.88	22.640	1.0005	1.0007	-0.024	0.02	3.9	2.0
13	5: 54:15	1.781	0.9976	1.0009	0.162	2.73	22.671	0.9996	0.9994	-0.001	0.02	3.9	2.0
14	5: 54:35	1.785	0.9990	1.0003	0.419	2.73	22.682	0.9999	0.9999	-0.000	0.02	3.9	2.0
15	5: 54:54	1.924	0.9983	1.0003	0.161	2.53	22.721	0.9999	1.0001	-0.000	0.02	3.9	2.0
16	5: 55:11	2.058	0.9977	1.0007	0.084	2.37	22.720	1.0001	1.0000	0.003	0.02	3.9	2.0
17	5: 55:41	2.057	1.0000	1.0000	-0.052	2.37	22.717	1.0007	1.0003	0.002	0.02	3.9	2.0
18	5: 55:49	2.182	0.9865	1.0028	0.101	2.25	22.655	1.0001	0.9999	-0.003	0.02	3.9	2.0
19	5: 55:57	2.302	0.9886	1.0024	0.110	2.13	22.577	1.0003	1.0000	0.003	0.02	3.9	2.0
20	5: 56: 4	2.427	0.9888	1.0022	0.114	2.02	22.518	0.9995	0.9996	-0.002	0.02	3.9	2.0
21	5: 56:12	2.689	0.9831	1.0029	0.125	1.83	22.494	1.0003	1.0000	0.001	0.02	3.9	2.0
22	5: 56:20	2.968	0.9857	1.0015	0.101	1.66	22.548	1.0000	1.0001	0.000	0.02	3.9	2.0
23	5: 56:28	3.251	0.9847	1.0013	0.125	1.52	22.571	1.0008	1.0005	-0.010	0.02	3.9	2.0
24	5: 56:54	3.536	0.9941	1.0010	0.075	1.40	22.489	0.9993	0.9997	-0.006	0.02	3.9	2.0
25	5: 57: 2	3.873	0.9923	1.0005	0.166	1.28	22.256	0.9995	0.9995	-0.001	0.02	3.9	2.0
26	5: 57:10	4.398	0.9918	1.0002	0.082	1.12	21.986	0.9996	0.9998	-0.004	0.02	3.9	2.0
27	5: 57:19	4.947	0.9946	1.0003	0.089	1.00	22.033	0.9999	0.9996	-0.002	0.02	3.9	2.0
28	5: 57:25	5.635	0.9644	1.0006	0.103	0.88	22.094	1.0001	1.0003	0.002	0.02	3.9	0.0
29	5: 57:32	6.963	0.9617	1.0005	0.111	0.71	22.066	1.0004	0.9999	-0.010	0.02	3.9	0.0
30	5: 57:38	8.554	0.9769	1.0008	0.116	0.58	21.334	0.9972	0.9992	0.004	0.02	3.9	0.0

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
RHO/S.I MAT PHASE I

TABLE A-3. SHOCK LAYER DATA (CONT'D)

DATE COMPUTED 22-JUL-81
TIME COMPUTED 06:23:24
DATE RECORDED 24-APR-81
TIME RECORDED 5:51:22
PROJECT NUMBER C145VB

PAGE 7
RUN 54 ALPHA SECTOR= 1.99 DEG
M = 7.97 ALPHAP = -10.01 DEG
RE = 3.623E+06 MODEL-ROLL = 180.00 DEG

CONFIGURATION 10.5/7-DEG BICONIC/SS+OS
NOSE RADIUS,IN 0.5000
TRIP .06 MACHINED
FLAP NONE

DATA TYPE : 3, SURVEY-PP AND TT
PRESSURE STABILIZATION STATISTICS
KNPP= 0.100 APP = 0.100
KNPPU= 1.000 APPU = 0.030

POINT	TIME HR:MIN:SEC	PP (PSIA)	PP1/PPF	PP/PPF	KPP	TNPP (SEC)	PPU (PSIA)	PPU1/PPUF	PPU/PPUF	KPPU	TNPPU (SEC)	TREC (SEC)	TDEL (SEC)
31	5: 57:45	10.484	0.9795	0.9989	0.094	0.47	7.620	1.0539	1.0063	0.150	0.07	3.9	0.0
32	5: 57:52	11.815	0.9934	0.9997	0.083	0.42	7.147	1.0004	0.9992	-0.012	0.07	3.9	0.0
33	5: 57:59	12.264	0.9993	0.9999	0.028	0.41	7.142	1.0013	1.0006	0.012	0.07	3.9	0.0
34	5: 58: 5	12.297	0.9993	0.9999	-0.008	0.40	7.140	1.0000	1.0003	0.011	0.07	3.9	0.0
35	5: 58:12	12.346	1.0002	1.0003	-0.001	0.40	7.139	1.0000	1.0010	0.000	0.07	3.9	0.0
36	5: 58:19	12.393	0.9990	1.0001	0.068	0.40	7.136	0.9992	1.0002	0.053	0.07	3.9	0.0
37	5: 58:26	12.415	0.9995	0.9998	-0.003	0.40	7.134	1.0000	1.0003	0.004	0.07	3.9	0.0
38	5: 58:32	12.402	1.0007	1.0004	-0.003	0.40	7.129	1.0008	0.9996	0.033	0.07	3.9	0.0
39	5: 58:39	12.387	0.9995	0.9999	0.007	0.40	7.127	0.9992	0.9998	-0.006	0.07	3.9	0.0
40	5: 58:46	12.391	0.9990	0.9998	-0.005	0.40	7.125	1.0013	1.0011	0.018	0.07	3.9	0.0
41	5: 58:53	12.433	1.0002	1.0001	0.004	0.40	7.121	1.0000	1.0005	0.019	0.07	3.9	0.0
42	5: 59: 0	12.482	0.9993	0.9996	0.003	0.40	7.123	0.9996	1.0005	-0.000	0.07	3.9	0.0
43	5: 59: 9	12.670	0.9993	1.0001	0.016	0.39	7.119	1.0008	1.0011	0.021	0.07	3.9	0.0
44	5: 59:17	13.247	0.9989	1.0002	0.029	0.38	7.118	0.9996	0.9998	0.012	0.07	3.9	0.0
45	5: 59:25	14.091	0.9987	0.9998	0.027	0.35	7.117	1.0008	1.0004	-0.019	0.07	3.9	0.0
46	5: 59:34	14.888	0.9986	0.9992	0.009	0.33	7.116	1.0000	1.0003	0.004	0.07	3.9	0.0
47	5: 59:42	15.584	0.9994	1.0001	0.018	0.32	7.113	0.9983	0.9994	0.017	0.07	3.9	0.0
48	5: 59:51	16.164	1.0002	1.0003	-0.000	0.31	7.111	1.0000	0.9992	-0.000	0.07	3.9	0.0
49	5: 59:59	17.100	0.9990	0.9995	-0.004	0.29	7.112	1.0000	0.9997	-0.005	0.07	3.9	0.0
50	6: 0: 8	18.164	1.0007	1.0004	-0.007	0.27	7.117	0.9996	1.0001	0.010	0.07	3.9	0.0
51	6: 0:16	19.227	0.9994	0.9999	0.010	0.26	7.121	1.0004	0.9998	0.004	0.07	3.9	0.0
52	6: 0:25	20.529	0.9990	0.9998	0.020	0.24	7.128	1.0000	1.0000	-0.003	0.07	3.9	0.0
53	6: 0:33	21.805	0.9997	0.9998	0.000	0.23	7.136	1.0000	1.0002	-0.007	0.07	3.9	0.0
54	6: 0:42	22.530	0.9999	0.9998	-0.002	0.22	7.139	1.0000	1.0001	-0.000	0.07	3.9	0.0
55	6: 0:50	22.463	0.9991	0.9997	0.004	0.22	7.143	0.9987	0.9994	-0.013	0.07	3.9	0.0
56	6: 0:59	21.904	0.9999	0.9998	0.001	0.23	7.143	1.0004	1.0007	0.016	0.07	3.9	0.0
57	6: 1: 7	21.934	1.0003	1.0002	0.002	0.23	7.143	1.0008	1.0007	0.006	0.07	3.9	0.0
58	6: 1:16	7.094	1.0506	0.9999	0.105	0.70	7.143	1.0000	1.0003	-0.000	0.07	3.9	0.0
59	6: 1:24	7.088	0.9996	0.9995	0.001	0.70	7.142	0.9996	1.0005	0.009	0.07	3.9	0.0
60	6: 1:35	7.073	1.0004	0.9998	0.005	0.70	7.134	0.9992	0.9994	0.007	0.07	3.9	0.0

RUN 54

PT =	834.52	PSIA	V =	3885.7	FT/SEC
TT =	1355.4	DEGR	Q =	3.887	PSIA
P =	0.0873	PSIA	T =	98.8	DEGR
RE =	3.623E+06	PER FT	PT2 =	7.19	PSIA
MU =	7.952E-08	LBF-SEC/FT2	RHO =	2.385E-03	LBM/FT3
DEW=	-52.	DEG F	C.R.=	24.06	IN

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
RMO/SAI MAT PHASE I

TABLE A-3. SHOCK LAYER DATA (CONT'D)

DATE COMPUTED 27-JUL-81
TIME COMPUTED 06:23:25
DATE RECORDED 24-APR-81
TIME RECORDED 5:51:22
PROJECT NUMBER C145V8

PAGE 8
RUN 54
M = 7.97
RE = 3.623E+06

ALPHA SECTOR= 1.99 DEG
ALPHAP = -10.01 DEG
MODEL-ROLL = 180.00 DEG

CONFIGURATION 10.5/7-DEG BICONIC/SS+DS

NOSE RADIUS,IN 0.5000

TRIP .06 MACHINED

FLAP NONE

DATA TYPE : 3, SURVEY- PP AND TT
MODEL SURFACE TEMPERATURES

POINT	TG 1 / TG 2 DEGR	TG 3 / TG 4 DEGR	TG 5 / TG 6 DEGR	TG 7 / TG 8 DEGR	TG 9 / TG 10 DEGR	TG 11 / TG 12 DEGR	TG 13 / TG 14 DEGR	TG 15 / TG 16 DEGR	TG102 / TG104 DEGR	TG106 / TG108 DEGR	TG110 / TG112 DEGR	TG114 / TG116 DEGR	TG11U / TG120 DEGR	TG122 DEGR
1		1140.	1082.	1109.	1081.							1200.		
	1163.	1131.				1012.			1216.	1188.			1196.	1192.
2		1143.	1082.	1109.	1081.							1201.		
	1163.	1131.				1012.			1217.	1190.			1197.	1193.
3		1141.	1082.	1109.	1081.							1200.		
	1163.	1131.				1012.			1214.	1181.			1196.	1192.
4		1141.	1082.	1109.	1081.							1200.		
	1163.	1131.				1012.			1216.	1189.			1197.	1192.
5		1140.	1082.	1109.	1081.							1200.		
	1163.	1131.				1012.			1215.	1184.			1196.	1191.
6		1139.	1082.	1109.	1081.							1199.		
	1163.	1131.				1012.			1213.	1180.			1196.	1191.
7		1140.	1082.	1109.	1081.							1200.		
	1163.	1131.				1012.			1215.	1183.			1196.	1192.
8		1138.	1081.	1109.	1081.							1200.		
	1163.	1131.				1012.			1215.	1187.			1196.	1190.
9		1137.	1081.	1109.	1081.							1199.		
	1163.	1131.				1012.			1213.	1180.			1196.	1190.
10		1140.	1081.	1109.	1081.							1200.		
	1163.	1131.				1012.			1214.	1176.			1196.	1191.
11		1139.	1081.	1109.	1081.							1199.		
	1163.	1131.				1012.			1214.	1177.			1196.	1191.
12		1141.	1081.	1109.	1081.							1200.		
	1163.	1131.				1012.			1215.	1178.			1196.	1192.
13		1143.	1081.	1109.	1081.							1200.		
	1163.	1131.				1012.			1216.	1183.			1196.	1193.
14		1141.	1081.	1109.	1081.							1200.		
	1163.	1131.				1012.			1214.	1180.			1196.	1192.
15		1139.	1081.	1109.	1081.							1199.		
	1163.	1131.				1012.			1215.	1182.			1196.	1191.
16		1139.	1081.	1109.	1081.							1199.		
	1163.	1131.				1012.			1214.	1178.			1196.	1191.
17		1141.	1081.	1109.	1081.							1200.		
	1163.	1131.				1012.			1214.	1181.			1196.	1192.

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BMO/SAI MAT PHASE I

TABLE A-3. SHOCK LAYER DATA (CONT'D)

DATE COMPUTED 22-JUL-81
TIME COMPUTED 06:23:25
DATE RECORDED 24-APR-81
TIME RECORDED 5:51:22
PROJECT NUMBER C145VB

PAGE 9			CONFIGURATION	NOSE RADIUS,IN	TRIP	FLAP
RUN 54	ALPHA SECTOR=	1.99 DEG	10.5/7-DEG BICONIC/SS+DS	0.5000	.06 MACHINED	NONE
M = 7.97	ALPHAP =	-10.01 DEG				
RE = 3.623E+06	MODEL-ROLL =	180.00 DEG				

DATA TYPE : 3, SURVEY- PP AND TT
MODEL SURFACE TEMPERATURES

POINT	TG 1 TG 2 DEGR	TG 3 TG 4 DEGR	TG 5 TG 6 DEGR	TG 7 TG 8 DEGR	TG 9 TG 10 DEGR	TG 11 TG 12 DEGR	TG 13 TG 14 DEGR	TG 15 TG 16 DEGR	TG102 TG104 DEGR	TG106 TG108 DEGR	TG110 TG112 DEGR	TG114 TG116 DEGR	TG118 TG120 DEGR	TG122 DEGR
18		1141.	1080.	1109.	1081.							1200.		
	1163.	1131.				1012.			1215.	1182.			1196.	1192.
19		1141.	1080.	1109.	1081.							1200.		
	1163.	1131.				1012.			1216.	1186.			1196.	1192.
20		1139.	1080.	1109.	1081.							1199.		
	1163.	1131.				1012.			1212.	1170.			1196.	1191.
21		1139.	1080.	1109.	1081.							1199.		
	1163.	1131.				1012.			1213.	1176.			1196.	1191.
22		1139.	1080.	1109.	1081.							1199.		
	1163.	1131.				1012.			1213.	1170.			1196.	1191.
23		1140.	1080.	1109.	1081.							1199.		
	1163.	1131.				1012.			1214.	1176.			1196.	1191.
24		1140.	1080.	1109.	1081.							1200.		
	1163.	1131.				1012.			1216.	1190.			1196.	1191.
25		1140.	1080.	1109.	1081.							1199.		
	1163.	1131.				1012.			1214.	1183.			1196.	1191.
26		1139.	1080.	1109.	1081.							1199.		
	1163.	1131.				1012.			1213.	1177.			1196.	1191.
27		1141.	1080.	1109.	1081.							1199.		
	1163.	1131.				1012.			1215.	1186.			1196.	1191.
28		1142.	1080.	1109.	1081.							1200.		
	1163.	1131.				1012.			1216.	1191.			1196.	1192.
29		1140.	1080.	1109.	1081.							1199.		
	1163.	1131.				1012.			1214.	1184.			1196.	1191.
30		1137.	1079.	1109.	1081.							1198.		
	1163.	1131.				1012.			1212.	1177.			1196.	1189.
31		1140.	1079.	1109.	1081.							1199.		
	1163.	1131.				1012.			1214.	1178.			1196.	1191.
32		1142.	1079.	1109.	1081.							1200.		
	1163.	1131.				1012.			1216.	1193.			1196.	1192.
33		1140.	1079.	1109.	1081.							1200.		
	1163.	1131.				1012.			1215.	1187.			1196.	1191.
34		1136.	1079.	1109.	1081.							1198.		
	1163.	1131.				1012.			1212.	1180.			1196.	1189.

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BMO/SAI MAT PHASE I

TABLE A-3. SHOCK LAYER DATA (CONT'D)

DATE COMPUTED 22-JUL-81
TIME COMPUTED 06:23:26
DATE RECORDED 24-APR-81
TIME RECORDED 5:51:22
PROJECT NUMBER C145VB

PAGE 10
RUN 54 ALPHA SECTOR= 1.99 DEG
M = 7.97 ALPHAP = -10.01 DEG
RE = 3.623E+06 MODEL-ROLL = 180.00 DEG

CONFIGURATION: 10.5/7-DEG BICONIC/SS+DS
NOSE RADIUS,IN: 0.5000
TRIP: .06 MACHINED
FLAP: NONE

DATA TYPE : 3, SURVEY- PP AND TT
MODEL SURFACE TEMPERATURES

POINT	TG 1 / TG 2 DEGR	TG 3 / TC 4 DEGR	TG 5 / TG 6 DEGR	TG 7 / TG 8 DEGR	TG 9 / TG 10 DEGR	TG 11 / TG 12 DEGR	TG 13 / TG 14 DEGR	TG 15 / TG 16 DEGR	TG102 / TG104 DEGR	TG106 / TG108 DEGR	TG110 / TG112 DEGR	TG114 / TG116 DEGR	TG118 / TG120 DEGR	TG122 DEGR
35		1141.	1079.	1109.	1081.							1199.		
	1163.	1131.				1012.			1214.	1184.			1196.	1191.
36		1138.	1078.	1109.	1081.							1199.		
	1163.	1131.				1012.			1215.	1189.			1196.	1190.
37		1139.	1078.	1109.	1081.							1199.		
	1163.	1131.				1012.			1213.	1182.			1196.	1191.
38		1143.	1078.	1109.	1080.							1200.		
	1163.	1131.				1012.			1216.	1189.			1196.	1193.
39		1141.	1078.	1109.	1081.							1200.		
	1163.	1131.				1012.			1215.	1187.			1196.	1192.
40		1137.	1078.	1109.	1081.							1198.		
	1163.	1131.				1012.			1212.	1180.			1196.	1189.
41		1138.	1078.	1109.	1081.							1199.		
	1163.	1131.				1012.			1214.	1184.			1196.	1190.
42		1138.	1078.	1109.	1080.							1199.		
	1163.	1131.				1012.			1214.	1185.			1196.	1190.
43		1140.	1078.	1109.	1081.							1199.		
	1163.	1131.				1012.			1215.	1189.			1196.	1191.
44		1136.	1078.	1109.	1080.							1198.		
	1163.	1131.				1012.			1212.	1179.			1195.	1189.
45		1139.	1078.	1109.	1080.							1199.		
	1163.	1131.				1012.			1215.	1190.			1196.	1190.
46		1142.	1078.	1109.	1080.							1199.		
	1163.	1131.				1012.			1214.	1184.			1196.	1192.
47		1138.	1077.	1109.	1081.							1198.		
	1163.	1130.				1012.			1212.	1176.			1195.	1190.
48		1139.	1077.	1108.	1080.							1199.		
	1163.	1130.				1012.			1216.	1192.			1196.	1191.
49		1140.	1077.	1109.	1080.							1199.		
	1163.	1130.				1012.			1213.	1180.			1195.	1191.
50		1139.	1077.	1109.	1080.							1199.		
	1163.	1130.				1012.			1214.	1188.			1196.	1191.
51		1140.	1077.	1109.	1081.							1199.		
	1163.	1130.				1012.			1215.	1189.			1196.	1191.

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ARNOLD AIR FORCE STATION, TENNESSEE
BMO/SAI MAT PHASE I

DATE COMPUTED 22-JUL-81
TIME COMPUTED 06:23:27
DATE RECORDED 24-APR-81
TIME RECORDED 5:51:22
PROJECT NUMBER C145VB

TABLE A-3. SHOCK LAYER DATA (CONT'D)

PAGE 11
RUN 54 ALPHA SECTOR= 1.99 DEG
M = 7.97 ALPHAP = -10.01 DEG
RE = 3.623E+06 MODEL-ROLL = 180.00 DEG

CONFIGURATION	NOSE RADIUS,IN	TRIP	FLAP
10.5/7-DEG BICONIC/SS+DS	0.5000	.06 MACHINED	NONE

DATA TYPE : 3, SURVEY- PP AND TT
MODEL SURFACE TEMPERATURES

POINT	TG 1 TG 2 DEGR	TG 3 TG 4 DEGR	TG 5 TG 6 DEGR	TG 7 TG 8 DEGR	TG 9 TG 10 DEGR	TG 11 TG 12 DEGR	TG 13 TG 14 DEGR	TG 15 TG 16 DEGR	TG102 TG104 DEGR	TG106 TG108 DEGR	TG110 TG112 DEGR	TG114 TG116 DEGR	TG118 TG120 DEGR	TG122 DEGR
52		1138.	1077.	1109.	1081.							1199.		
	1163.	1130.				1012.			1214.	1185.			1196.	1190.
53		1140.	1077.	1109.	1080.							1199.		
	1163.	1130.				1012.			1215.	1191.			1196.	1191.
54		1142.	1077.	1109.	1080.							1200.		
	1163.	1131.				1012.			1216.	1193.			1196.	1192.
55		1139.	1077.	1109.	1080.							1199.		
	1163.	1131.				1012.			1213.	1177.			1195.	1190.
56		1139.	1077.	1108.	1080.							1199.		
	1163.	1130.				1012.			1214.	1189.			1196.	1190.
57		1139.	1077.	1108.	1080.							1199.		
	1163.	1130.				1012.			1215.	1188.			1196.	1191.
58		1138.	1077.	1108.	1080.							1199.		
	1163.	1130.				1012.			1214.	1189.			1196.	1190.
59		1140.	1077.	1109.	1080.							1199.		
	1162.	1130.				1012.			1215.	1190.			1196.	1191.
60		1140.	1077.	1109.	1080.							1199.		
	1163.	1130.				1012.			1214.	1190.			1196.	1191.

RUN 54

PT =	834.52	PSIA	V =	3885.7	FT/SEC
TT =	1355.4	DEGR	Q =	3.887	PSIA
P =	0.0873	PSIA	T =	98.8	DEGR
RE =	3.623E+06	PER FT	PT2 =	7.19	PSIA
MU =	7.952E-08	LBF-SEC/FT2	RHO =	2.385E-03	LBM/FT3
DEW=	-52.	DEG F	C.R.=	24.06	IN

(Reynolds number) corrected total temperature profiles, respectively. Figures A-14 and A-15 are the Pitot pressure profiles normalized by the local wall static pressure, P, (Figure A-14) and by the freestream Pitot pressure, PT2 (Figure A-15).

Boundary layer type analyses were performed using these data and the assumption that the static pressure in the shock layer was constant and equal to the local wall static pressure. Thus with the static pressure assumed and the local values of PT2 and TT, local state variables in the shock layer were defined including local values of the viscous layer thicknesses. Note, the assumption of constant static pressure is incorrect outside of the boundary layer and consequently the local derived properties in the "inviscid" flow are not valid. The reader is referred to Section 4 of the report for a discussion of this. Nevertheless, Table A-4 (4 pages) defines the derived local properties for the same data group defined in Table A-3. Figures A-16 through A-18 graphically define the derived local properties. One notes from Figure A-16 that the freestream Mach number (noted by the several data points at $ZP > 2.3$) is ~ 0.75 of the boundary layer edge Mach number, clearly incorrect.

The Mach/Flow-Angularity data tabulations for a given data group are contained in two tables sets, Table A-5 (9 pages) and Table A-6 (2 pages). Table A-5 defines the measured data while Table A-6 presents the computed flow direction results. The corresponding graphical presentation of these data are shown in Figure A-19 for the raw data and Figure A-20 for the derived properties.

A.5 Static Force Data

The force and moment measurements were reduced to coefficient form using digitally filtered data points and correcting for first and second order balance interaction effects. The coefficients were also corrected for model tare weight and balance-sting deflections. Model attitude and tunnel stilling chamber pressure were calculated from digitally filtered values.

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RMO/SAI MAT PHASE I

TABLE A-4. BOUNDARY LAYER AND SHOCK LAYER DERIVED DATA

PROJECT NUMBER C145V8

PAGE 1 | CONFIGURATION | NOSE RADIUS,IN | TRIP | FLAP
RUN 54 ALPHA SECTOR = 1.99 DEG | 10.5/7-DEG BICONIC/SS+DS | 0.5000 | .06 MACHINED | NONE
M = 7.97 ALPHAP = -10.01 DEG
RE = 3.623E+06 MODEL-ROLL = 180.00 DEG

DATA TYPE: 3, SURVEY-PP AND TT   SURVEY STATION 58   PWX/PT = 2.497E-04

LOCAL CONDITIONS AT THE PITOT PROBE

POINT	ZP (IN)	PP (PSIA)	TTLI (DEGR)	TWX (DEGR)	PP/PWX	PP/P	ML	TL (DEGR)	UL (FT/SEC)	RETD	PT (PSIA)	TT (DEGR)
1	0.0050	0.280	1156.6	1082.	1.344	3.207	0.66	1062.8	1061.4	1.104E+01	834.516	1355.4
2	0.0110	0.301	1165.0	1082.	1.444	3.445	0.74	1049.0	1180.8	1.239E+01	834.625	1355.4
3	0.0168	0.346	1184.6	1082.	1.659	3.959	0.88	1025.0	1384.6	1.471E+01	834.719	1355.4
4	0.0220	0.454	1211.4	1082.	2.180	5.200	1.12	969.5	1705.0	1.887E+01	834.559	1355.3
5	0.0258	0.535	1224.5	1082.	2.569	6.129	1.25	932.6	1872.7	2.140E+01	834.422	1355.3
6	0.0306	0.712	1245.3	1082.	3.417	8.153	1.50	859.4	2153.3	2.642E+01	834.465	1355.2
7	0.0362	0.930	1262.9	1082.	4.465	10.653	1.75	782.6	2402.4	3.208E+01	834.559	1355.1
8	0.0406	1.111	1273.6	1081.	5.330	12.717	1.94	727.9	2560.6	3.656E+01	834.489	1355.2
9	0.0170	1.339	1283.5	1081.	6.427	15.334	2.15	668.2	2719.1	4.209E+01	834.512	1355.2
10	0.0518	1.483	1288.3	1081.	7.118	16.984	2.27	635.1	2801.4	4.551E+01	834.565	1355.0
11	0.0565	1.599	1291.4	1081.	7.676	18.314	2.36	610.4	2860.4	4.827E+01	834.411	1354.9
12	0.0602	1.686	1293.3	1081.	8.094	19.312	2.43	593.1	2900.5	5.033E+01	834.447	1355.0
13	0.0654	1.781	1294.6	1081.	8.550	20.399	2.50	575.1	2940.4	5.259E+01	834.344	1354.9
14	0.0654	1.785	1294.5	1081.	8.565	20.436	2.50	575.3	2939.8	5.257E+01	834.578	1354.8
15	0.0754	1.924	1295.8	1081.	9.231	22.024	2.60	549.8	2994.0	5.599E+01	834.563	1354.7
16	0.0673	2.058	1296.2	1081.	9.873	23.556	2.70	527.5	3039.2	5.923E+01	834.670	1354.7
17	0.0671	2.057	1296.2	1081.	9.872	23.554	2.70	527.9	3038.4	5.917E+01	834.622	1354.7
18	0.0980	2.182	1297.1	1080.	10.469	24.978	2.78	508.7	3077.9	6.217E+01	834.625	1354.6
19	0.1086	2.302	1298.6	1080.	11.049	26.363	2.86	491.9	3113.4	6.498E+01	834.512	1354.6
20	0.1190	2.427	1300.7	1080.	11.647	27.789	2.94	476.0	3148.0	6.782E+01	834.455	1354.5
21	0.1377	2.689	1305.8	1080.	12.905	30.791	3.11	445.9	3214.5	7.376E+01	834.544	1354.4
22	0.1578	2.968	1311.4	1080.	14.244	33.985	3.27	418.1	3276.2	7.994E+01	834.476	1354.4
23	0.1764	3.251	1317.2	1080.	15.603	37.227	3.43	393.5	3331.5	8.613E+01	834.453	1354.5
24	0.1958	3.536	1322.9	1080.	16.966	40.480	3.58	371.6	3380.8	9.233E+01	834.646	1354.4
25	0.2153	3.873	1328.5	1080.	18.582	44.337	3.75	348.7	3431.4	9.961E+01	834.613	1354.4
26	0.2449	4.398	1336.3	1080.	21.104	50.353	4.00	318.0	3497.9	1.109E+02	834.674	1354.3
27	0.2746	4.947	1342.7	1080.	23.736	56.634	4.25	291.2	3554.6	1.227E+02	834.667	1354.4
28	0.3032	5.635	1347.0	1080.	27.030	64.492	4.54	263.0	3609.0	1.377E+02	831.845	1354.4
29	0.3422	6.963	1350.6	1080.	33.403	79.698	5.06	220.9	3684.2	1.671E+02	834.868	1354.3
30	0.3914	8.554	1352.3	1079.	41.033	97.903	5.61	185.3	3744.6	2.023E+02	834.635	1354.2
31	0.4197	10.484	1348.7	1079.	50.297	120.005	6.22	154.4	3788.2	2.461E+02	834.755	1354.3
32	0.4601	11.815	1338.5	1079.	56.679	135.232	6.61	137.6	3798.6	2.781E+02	834.847	1354.3
33	0.4985	12.204	1331.8	1079.	58.553	139.705	6.71	132.9	3795.4	2.885E+02	834.676	1354.2
34	0.5381	12.297	1329.8	1079.	58.993	140.754	6.74	131.8	3794.0	2.911E+02	834.796	1354.1
35	0.5755	12.346	1329.4	1079.	59.224	141.304	6.75	131.3	3794.1	2.923E+02	834.871	1354.2
36	0.6151	12.393	1329.3	1078.	59.444	141.831	6.77	130.9	3794.7	2.934E+02	834.894	1354.2
37	0.6546	12.415	1329.2	1078.	59.555	142.094	6.77	130.7	3794.9	2.939E+02	834.851	1354.1
38	0.6942	12.402	1329.2	1078.	59.497	141.957	6.77	130.8	3794.8	2.936E+02	834.776	1354.2
39	0.7329	12.387	1329.2	1078.	59.425	141.784	6.76	130.9	3794.6	2.933E+02	834.799	1354.3
40	0.7716	12.391	1329.1	1078.	59.440	141.821	6.77	130.9	3794.4	2.934E+02	834.874	1354.3

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PRO/SAT MAT PHASE I

TABLE A-4. BOUNDARY LAYER AND SHOCK LAYER DERIVED DATA (CONT'D)

PROJECT NUMBER C145VB

PAGE 2
RUN 54   ALPHA SECTOR= 1.99 DEG   CONFIGURATION 10.5/7-DEG BICONIC/S5+DS   NOSE RADIUS,IN 0.5000   TRIP .06 MACHINED   FLAP NONE
M = 7.97   ALPHAP = -10.01 DEG
RE = 3.623E+06   MODEL-PULL = 180.00 DEG

DATA TYPE: 3, SURVEY-PP AND TT   SURVEY STATION 58   PWX/PT = 2.497E-04

LOCAL CONDITIONS AT THE PITOT PROBE

POINT	ZP (IN)	PP (PSIA)	TTLI (DEGR)	TWX (DEGR)	PP/PWX	PP/P	ML	TL (DEGR)	UL (FT/SEC)	RETD	PT (PSIA)	TT (DEGR)
41	0.8306	12.433	1328.9	1078.	59.651	142.324	6.78	130.4	3794.8	2.944E+02	834.751	1354.1
42	0.8896	12.482	1328.7	1078.	59.872	142.852	6.79	130.0	3795.3	2.956E+02	834.916	1354.2
43	0.9361	12.670	1328.4	1078.	60.775	145.005	6.84	128.2	3797.6	2.999E+02	834.919	1354.2
44	1.0955	13.247	1327.2	1078.	63.541	151.605	7.00	123.0	3803.9	3.133E+02	834.692	1354.1
45	1.1817	14.091	1325.7	1078.	67.603	161.296	7.22	116.0	3812.4	3.330E+02	834.775	1354.2
46	1.2787	14.888	1324.5	1078.	71.424	170.414	7.42	110.2	3819.7	3.515E+02	834.794	1354.2
47	1.3756	15.584	1324.3	1077.	74.773	178.404	7.60	105.6	3826.7	3.674E+02	834.655	1354.2
48	1.4740	16.164	1324.1	1077.	77.569	185.074	7.74	102.1	3832.0	3.807E+02	834.544	1354.2
49	1.5706	17.100	1325.9	1077.	82.047	195.760	7.96	97.0	3842.6	4.014E+02	834.668	1354.2
50	1.6698	18.164	1329.7	1077.	87.150	207.935	8.20	92.0	3856.5	4.242E+02	834.712	1354.3
51	1.7667	19.227	1334.3	1077.	92.242	220.085	8.44	87.5	3870.5	4.466E+02	834.763	1354.3
52	1.8635	20.529	1338.4	1077.	98.482	234.973	8.72	82.5	3884.7	4.743E+02	834.809	1354.1
53	1.9616	21.805	1342.3	1077.	104.600	249.570	8.99	78.2	3897.4	5.014E+02	834.842	1354.2
54	2.0602	22.530	1343.4	1077.	108.097	257.914	9.14	75.8	3902.7	5.172E+02	834.692	1354.2
55	2.1559	22.463	1343.2	1077.	107.767	257.113	9.13	76.1	3902.0	5.158E+02	834.811	1354.1
56	2.2551	21.904	1342.2	1077.	105.084	250.725	9.01	77.8	3897.8	5.037E+02	834.775	1354.2
57	2.3503	21.934	1342.2	1077.	105.219	251.046	9.02	77.7	3897.8	5.044E+02	834.829	1354.2
58	2.4491	7.094	1363.0	1077.	34.033	81.202	5.10	219.5	3706.9	1.682E+02	834.793	1354.2
59	2.5475	7.088	1362.4	1077.	34.004	81.132	5.10	219.5	3705.7	1.682E+02	834.787	1354.3
60	2.7416	7.073	1359.0	1077.	33.930	80.956	5.10	219.4	3700.4	1.683E+02	834.793	1354.3

TUNNEL CONDITIONS(MEAN VALUES)

PT =	834.68	PSIA	V =	3884.4	FT/SEC
TT =	1354.5	DEGR	Q =	3.888	PSIA
P =	0.0874	PSIA	T =	98.8	DEGR
RE =	3.627E+06	PER FT	PT2 =	7.19	PSIA
MU =	7.947E-08	LBF-SEC/FT2	RHO =	2.387E-03	LBM/FT3
RUN	54				

ARVIN/CALSPAN FIELD SERVICES, INC.
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ARNOLD AIR FORCE STATION, TENNESSEE
RHO/SAI MAT PHASE I

TABLE A-4. BOUNDARY LAYER AND SHOCK LAYER DERIVED DATA (CONT'D)

PROJECT NUMBER C145VB

PAGE 3
RUN 54 ALPHA SECTOR= 1.99 DEG
M = 7.97 ALPHAP = -10.01 DEG
RE = 3.623E+06 MODEL-ROLL = 180.00 DEG

CONFIGURATION 10.5/7-DEG BICONIC/SS+DS
NOSE RADIUS,IN 0.5000
TRIP .06 MACHINED
FLAP NONE

DATA TYPE: 3, SURVEY-PP AND TT
BOUNDARY LAYER INTEGRAL EVALUATION

SURVEY STATION NO = 58

POINT	ZP/DEL	PP/PPE	ML/ME	TTL/TTE	TL/TE	RHOL/RHOE	UL/UE	MUTL/MUTE	REL/REE	RETTL/RETTE	DITTL/DITTE
1	1.087E-02	2.371E-02	1.005E-01	8.641E-01	7.723E+00	1.294E-01	2.794E-01	5.636E+00	6.417E-03	3.969E-02	2.844E-01
2	2.380E-02	2.547E-02	1.126E-01	8.704E-01	7.623E+00	1.312E-01	3.109E-01	5.587E+00	7.297E-03	4.454E-02	3.165E-01
3	3.647E-02	2.927E-02	1.336E-01	8.850E-01	7.448E+00	1.342E-01	3.645E-01	5.502E+00	8.897E-03	5.288E-02	3.912E-01
4	4.781E-02	3.844E-02	1.691E-01	9.051E-01	7.045E+00	1.419E-01	4.488E-01	5.302E+00	1.201E-02	6.785E-02	4.946E-01
5	5.600E-02	4.530E-02	1.894E-01	9.148E-01	6.777E+00	1.475E-01	4.930E-01	5.166E+00	1.407E-02	7.693E-02	5.452E-01
6	6.642E-02	6.026E-02	2.268E-01	9.304E-01	6.245E+00	1.601E-01	5.669E-01	4.886E+00	1.857E-02	9.497E-02	6.257E-01
7	7.672E-02	7.875E-02	2.652E-01	9.435E-01	5.687E+00	1.758E-01	6.374E-01	4.578E+00	2.479E-02	1.153E-01	6.940E-01
8	8.817E-02	9.400E-02	2.911E-01	9.515E-01	5.289E+00	1.890E-01	6.741E-01	4.349E+00	2.929E-02	1.313E-01	7.364E-01
9	1.021E-01	1.133E-01	3.249E-01	9.589E-01	4.856E+00	2.059E-01	7.158E-01	4.088E+00	3.605E-02	1.513E-01	7.752E-01
10	1.125E-01	1.255E-01	3.413E-01	9.625E-01	4.615E+00	2.166E-01	7.375E-01	3.939E+00	4.055E-02	1.636E-01	7.935E-01
11	1.227E-01	1.354E-01	3.575E-01	9.648E-01	4.436E+00	2.253E-01	7.530E-01	3.825E+00	4.436E-02	1.736E-01	8.059E-01
12	1.308E-01	1.427E-01	3.678E-01	9.662E-01	4.310E+00	2.319E-01	7.636E-01	3.743E+00	4.731E-02	1.810E-01	8.134E-01
13	1.427E-01	1.508E-01	3.787E-01	9.672E-01	4.179E+00	2.392E-01	7.741E-01	3.657E+00	5.062E-02	1.891E-01	8.188E-01
14	1.421E-01	1.511E-01	3.785E-01	9.672E-01	4.180E+00	2.391E-01	7.739E-01	3.658E+00	5.059E-02	1.890E-01	8.189E-01
15	1.640E-01	1.628E-01	3.943E-01	9.681E-01	3.995E+00	2.502E-01	7.882E-01	3.534E+00	5.581E-02	2.013E-01	8.242E-01
16	1.898E-01	1.742E-01	4.087E-01	9.684E-01	3.833E+00	2.608E-01	8.001E-01	3.423E+00	6.096E-02	2.130E-01	8.268E-01
17	1.892E-01	1.741E-01	4.084E-01	9.684E-01	3.836E+00	2.606E-01	7.999E-01	3.425E+00	6.086E-02	2.127E-01	8.272E-01
18	2.131E-01	1.847E-01	4.214E-01	9.691E-01	3.697E+00	2.704E-01	8.103E-01	3.328E+00	6.584E-02	2.235E-01	8.312E-01
19	2.364E-01	1.949E-01	4.335E-01	9.702E-01	3.575E+00	2.796E-01	8.196E-01	3.242E+00	7.070E-02	2.336E-01	8.381E-01
20	2.564E-01	2.054E-01	4.456E-01	9.718E-01	3.459E+00	2.890E-01	8.287E-01	3.158E+00	7.587E-02	2.438E-01	8.460E-01
21	2.993E-01	2.276E-01	4.701E-01	9.756E-01	3.240E+00	3.085E-01	8.462E-01	2.997E+00	8.711E-02	2.652E-01	8.659E-01
22	3.430E-01	2.517E-01	4.968E-01	9.798E-01	3.038E+00	3.290E-01	8.625E-01	2.844E+00	9.976E-02	2.874E-01	8.881E-01
23	3.833E-01	2.752E-01	5.196E-01	9.841E-01	2.860E+00	3.495E-01	8.770E-01	2.705E+00	1.133E-01	3.097E-01	9.106E-01
24	4.255E-01	2.993E-01	5.416E-01	9.883E-01	2.700E+00	3.702E-01	8.900E-01	2.578E+00	1.278E-01	3.319E-01	9.336E-01
25	4.678E-01	3.278E-01	5.675E-01	9.926E-01	2.534E+00	3.946E-01	9.033E-01	2.441E+00	1.460E-01	3.581E-01	9.552E-01
26	5.322E-01	3.723E-01	6.057E-01	9.984E-01	2.311E+00	4.326E-01	9.208E-01	2.252E+00	1.769E-01	3.988E-01	9.857E-01
27	5.966E-01	4.187E-01	6.433E-01	1.003E+00	2.116E+00	4.725E-01	9.358E-01	2.081E+00	2.124E-01	4.413E-01	1.010E+00
28	6.590E-01	4.769E-01	6.873E-01	1.006E+00	1.911E+00	5.233E-01	9.501E-01	1.895E+00	2.623E-01	4.952E-01	1.028E+00
29	7.438E-01	5.894E-01	7.654E-01	1.009E+00	1.606E+00	6.226E-01	9.699E-01	1.606E+00	3.761E-01	6.007E-01	1.043E+00
30	8.299E-01	7.239E-01	8.494E-01	1.010E+00	1.347E+00	7.425E-01	9.858E-01	1.347E+00	5.435E-01	7.273E-01	1.051E+00
31	9.172E-01	8.873E-01	9.415E-01	1.008E+00	1.122E+00	8.913E-01	9.972E-01	1.127E+00	7.923E-01	8.846E-01	1.037E+00
32	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	9.982E-01
33	1.083E+00	1.033E+00	1.017E+00	9.950E-01	9.661E-01	1.035E+00	9.991E-01	9.661E-01	1.070E+00	1.037E+00	9.721E-01
34	1.170E+00	1.041E+00	1.020E+00	9.935E-01	9.581E-01	1.044E+00	9.988E-01	9.581E-01	1.088E+00	1.047E+00	9.653E-01
35	1.251E+00	1.045E+00	1.022E+00	9.932E-01	9.544E-01	1.048E+00	9.988E-01	9.544E-01	1.097E+00	1.051E+00	9.636E-01
36	1.337E+00	1.049E+00	1.024E+00	9.931E-01	9.511E-01	1.051E+00	9.990E-01	9.511E-01	1.104E+00	1.055E+00	9.642E-01
37	1.423E+00	1.051E+00	1.025E+00	9.931E-01	9.495E-01	1.053E+00	9.990E-01	9.495E-01	1.108E+00	1.057E+00	9.638E-01
38	1.509E+00	1.050E+00	1.025E+00	9.931E-01	9.503E-01	1.052E+00	9.990E-01	9.503E-01	1.106E+00	1.056E+00	9.642E-01
39	1.593E+00	1.048E+00	1.024E+00	9.931E-01	9.514E-01	1.051E+00	9.989E-01	9.514E-01	1.104E+00	1.055E+00	9.646E-01
40	1.677E+00	1.049E+00	1.024E+00	9.930E-01	9.511E-01	1.051E+00	9.989E-01	9.511E-01	1.104E+00	1.055E+00	9.646E-01

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
RHO/SAT MAT PHASE I

TABLE A-4. BOUNDARY LAYER AND SHOCK LAYER DERIVED DATA (CONT'D)

PROJECT NUMBER C145VB

PAGE 4
RUN 54 ALPHA SECTOR= 1.99 DEG
M = 7.97 ALPHAP = -10.01 DEG
RE = 3.623E+06 MODEL-ROLL = 180.00 DEG

CONFIGURATION 10.5/7-DEG BICONIC/SS+DS | NOSE RADIUS,IN 0.5000 | TRIP .06 MACHINED | FLAP NONE

DATA TYPE: 3, SURVEY-PP AND TT SURVEY STATION NO = 58
BOUNDARY LAYER INTEGRAL EVALUATION

POINT	ZP/DEL	PP/PPE	ML/ME	TTL/TTE	TL/TE	RHOL/RHOE	UL/UE	MUTL/MUTE	REL/REE	RETTL/RETTE	DITTL/DITTE
41	1.805E+00	1.052E+00	1.026E+00	9.928E-01	9.479E-01	1.055E+00	9.990E-01	9.479E-01	1.112E+00	1.059E+00	9.644E-01
42	1.934E+00	1.056E+00	1.028E+00	9.927E-01	9.446E-01	1.059E+00	9.991E-01	9.446E-01	1.120E+00	1.063E+00	9.639E-01
43	2.143E+00	1.072E+00	1.036E+00	9.925E-01	9.316E-01	1.074E+00	9.997E-01	9.316E-01	1.152E+00	1.078E+00	9.629E-01
44	2.359E+00	1.121E+00	1.059E+00	9.916E-01	8.937E-01	1.119E+00	1.001E+00	8.937E-01	1.254E+00	1.127E+00	9.588E-01
45	2.568E+00	1.193E+00	1.093E+00	9.904E-01	8.433E-01	1.186E+00	1.004E+00	8.433E-01	1.411E+00	1.197E+00	9.532E-01
46	2.779E+00	1.260E+00	1.124E+00	9.895E-01	8.009E-01	1.249E+00	1.006E+00	8.009E-01	1.568E+00	1.264E+00	9.488E-01
47	2.990E+00	1.319E+00	1.150E+00	9.894E-01	7.676E-01	1.302E+00	1.007E+00	7.676E-01	1.709E+00	1.321E+00	9.483E-01
48	3.204E+00	1.368E+00	1.171E+00	9.893E-01	7.418E-01	1.348E+00	1.009E+00	7.418E-01	1.832E+00	1.369E+00	9.475E-01
49	3.414E+00	1.447E+00	1.205E+00	9.906E-01	7.050E-01	1.418E+00	1.012E+00	7.050E-01	2.035E+00	1.443E+00	9.547E-01
50	3.629E+00	1.537E+00	1.242E+00	9.935E-01	6.683E-01	1.496E+00	1.015E+00	6.683E-01	2.273E+00	1.525E+00	9.700E-01
51	3.840E+00	1.627E+00	1.278E+00	9.969E-01	6.358E-01	1.573E+00	1.019E+00	6.358E-01	2.520E+00	1.605E+00	9.879E-01
52	4.050E+00	1.737E+00	1.321E+00	1.000E+00	5.997E-01	1.667E+00	1.023E+00	5.997E-01	2.843E+00	1.705E+00	1.004E+00
53	4.263E+00	1.845E+00	1.361E+00	1.003E+00	5.681E-01	1.760E+00	1.026E+00	5.681E-01	3.179E+00	1.803E+00	1.020E+00
54	4.478E+00	1.907E+00	1.384E+00	1.004E+00	5.512E-01	1.814E+00	1.027E+00	5.512E-01	3.381E+00	1.859E+00	1.025E+00
55	4.686E+00	1.901E+00	1.382E+00	1.004E+00	5.527E-01	1.809E+00	1.027E+00	5.527E-01	3.363E+00	1.854E+00	1.024E+00
56	4.901E+00	1.854E+00	1.364E+00	1.003E+00	5.656E-01	1.768E+00	1.026E+00	5.656E-01	3.207E+00	1.811E+00	1.020E+00
57	5.108E+00	1.856E+00	1.365E+00	1.003E+00	5.649E-01	1.770E+00	1.026E+00	5.649E-01	3.216E+00	1.813E+00	1.020E+00
58	5.323E+00	6.004E-01	7.727E-01	1.018E+00	1.595E+00	6.270E-01	9.758E-01	1.596E+00	3.834E-01	6.049E-01	1.102E+00
59	5.537E+00	5.999E-01	7.724E-01	1.018E+00	1.595E+00	6.268E-01	9.755E-01	1.596E+00	3.831E-01	6.047E-01	1.099E+00
60	5.959E+00	5.986E-01	7.715E-01	1.015E+00	1.594E+00	6.272E-01	9.741E-01	1.595E+00	3.831E-01	6.052E-01	1.086E+00

*********** EDGE VALUES ***********

DEL = 4.601E-01 INCH	DEL*/DEL** = 20.0615	PPE = 1.182E+01 PSIA	RHOE = 4.089E-03 LBM/FT3
DEL* = 2.620E-01 INCH		ME = 6.605E+00	RHOUE = 1.553E+01 LBM/SEC-FT2
DEL** = 1.306E-02 INCH	DEL**/DEL3 = 0.5464	TTE = 1.338E+03 DEGR	MUTE = 1.106E-07 LBF-SEC/FT2
DEL3 = 2.390E-02 INCH		TE = 1.376E+02 DEGR	REE = 3.636E+05 PER INCH
DEL4 = 3.216E-04 INCH		UE = 3.799E+03 FT/SEC	RETTE = 5.562E+04 PER INCH
			DITTE = 6.662E+01 BTU/LBM

RUN 54

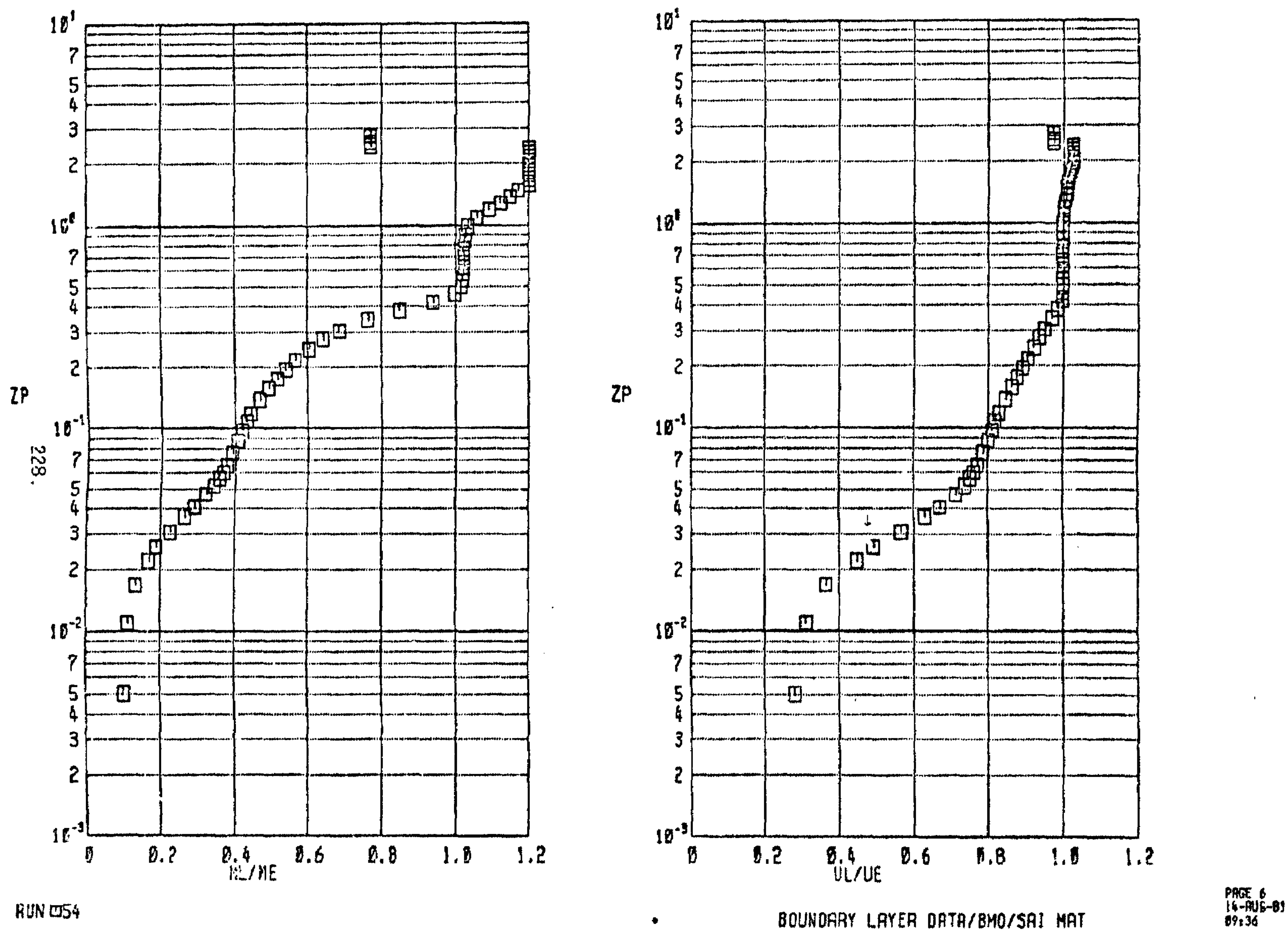


FIGURE A-16. DERIVED LOCAL MACH NUMBER AND VELOCITY DATA

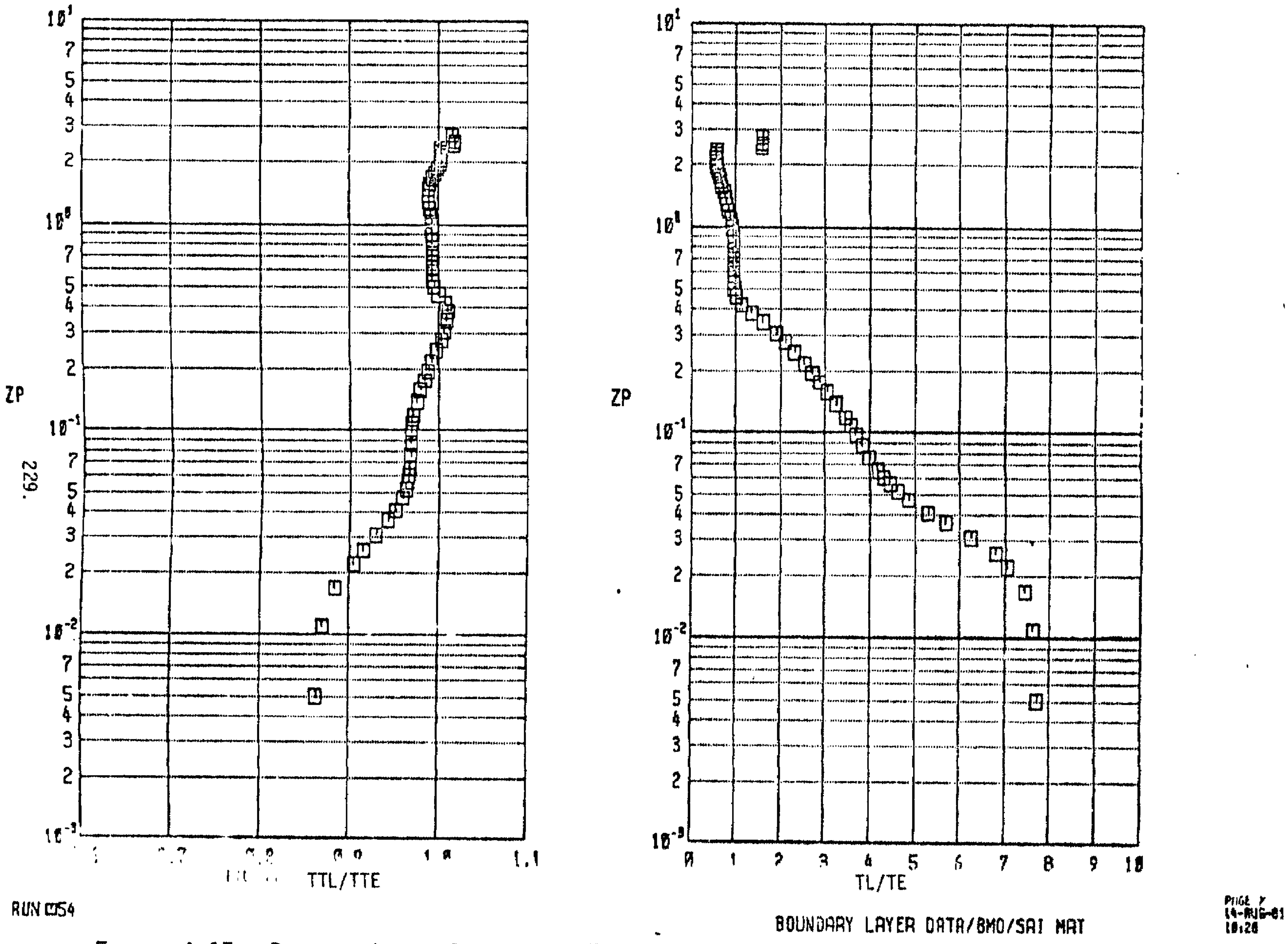
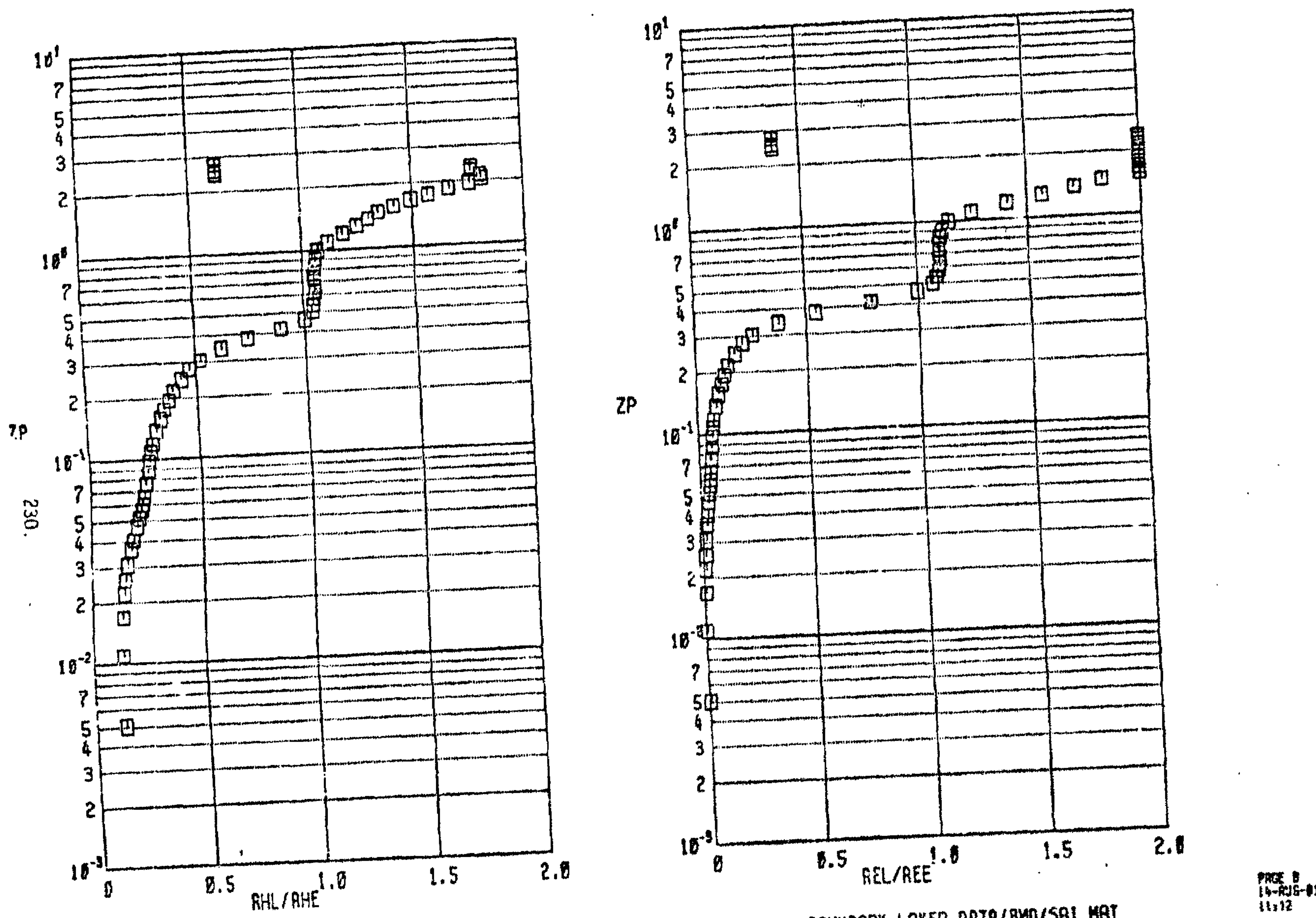


FIGURE A-17. DERIVED LOCAL STATIC AND TOTAL TEMPERATURE DATA



RUN 054

FIGURE A-18. DERIVED LOCAL DENSITY AND REYNOLDS NUMBER DATA

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
BMO/SAI MAT PHASE 7

TABLE A-5. MACH/FLOW-ANGULARITY PROBE MEASURED DATA

TIME COMPUTED 13:22:51
DATE RECORDED 30-APR-81
TIME RECORDED 9: 3:57
PROJECT NUMBER C145VB

PAGE 1

RUN	218	ALPHA SECTOR=	-8.01 DEG	CONFIGURATION	NOSE RADIUS,IN	TRIP	FLAP
M =	7.97	ALPHAP =	-20.01 DEG	10.5/7-DEG BICONIC/SS+DS	0.5000	.06 MACHINED	NONE
RE =	3.627E+06	MODEL-ROLL =	180.00 DEG				

DATA TYPE: 2, SURVEY-MACH/ FLOW ANGULARITY PROBE   SURVEY STATION NO = 39   PWX/PT= 1.109E-03

TEST CONDITIONS AND LOCAL CONDITIONS FROM P5 OF THE MACH/FLOW ANGULARITY PROBE

POINT	PT (PSIA)	TT (DEGR)	P (PSIA)	PT2 (PSIA)	ZM (IN)	P5 (PSIA)	P5/PT2	P5/P	P5/PWX	ML	TREC (SEC)	TDEL (SEC)
1	833.22	1352.8	0.087	7.179	0.0220	5.362	0.7469	61.49	5.80	2.03	23.4	10.0
2	833.73	1352.4	0.087	7.183	0.0482	7.121	0.9913	81.61	7.70	2.37	7.8	2.0
3	833.42	1352.3	0.087	7.181	0.0581	8.380	1.1670	96.08	9.07	2.58	7.8	2.0
4	833.15	1352.0	0.087	7.178	0.0675	9.357	1.3035	107.31	10.13	2.74	7.8	2.0
5	833.11	1351.8	0.087	7.178	0.0773	10.206	1.4219	117.06	11.05	2.86	7.8	2.0
6	832.75	1351.6	0.087	7.175	0.0877	11.099	1.5469	127.35	12.02	2.99	7.8	2.0
7	832.69	1351.4	0.087	7.174	0.0977	11.909	1.6601	136.67	12.90	3.10	7.8	2.0
8	834.12	1351.3	0.087	7.186	0.1082	12.737	1.7723	145.90	13.77	3.21	7.8	2.0
9	834.28	1351.0	0.087	7.188	0.1173	13.413	1.8661	153.61	14.50	3.30	7.8	2.0
10	834.76	1350.5	0.087	7.192	0.1171	13.699	1.9049	156.81	14.80	3.33	7.8	2.0
11	834.97	1350.3	0.087	7.193	0.1264	14.376	1.9985	164.51	15.53	3.42	7.8	2.0
12	834.84	1350.2	0.087	7.192	0.1398	14.845	2.0639	169.90	16.03	3.47	7.8	2.0
13	834.68	1350.1	0.087	7.191	0.1492	15.111	2.1009	172.94	16.32	3.51	7.8	2.0
14	835.62	1350.1	0.087	7.199	0.1686	15.412	2.1409	176.23	16.63	3.54	7.8	2.0
15	836.02	1350.0	0.087	7.202	0.1887	15.614	2.1679	178.45	16.84	3.56	7.8	2.0
16	836.11	1350.0	0.088	7.203	0.2073	15.795	2.1929	180.51	17.03	3.58	7.8	2.0
17	836.22	1349.9	0.088	7.204	0.2270	16.059	2.2292	183.49	17.32	3.62	7.8	2.0
18	836.40	1349.9	0.088	7.205	0.2483	16.460	2.2844	188.03	17.74	3.66	7.8	2.0
19	836.54	1349.9	0.088	7.206	0.2759	17.109	2.3741	195.41	18.44	3.73	7.8	2.0
20	835.09	1349.8	0.087	7.194	0.3059	17.822	2.4772	203.92	19.24	3.82	7.8	2.0
21	834.97	1349.8	0.087	7.193	0.3346	18.374	2.5542	210.26	19.84	3.88	7.8	2.0
22	835.25	1349.8	0.087	7.196	0.3735	18.825	2.6161	215.35	20.32	3.92	7.8	2.0
23	835.29	1349.8	0.087	7.196	0.4133	19.026	2.6439	217.64	20.54	3.95	7.8	2.0
24	835.19	1349.8	0.087	7.195	0.4512	19.103	2.6549	218.54	20.62	3.95	7.8	2.0
25	835.10	1349.8	0.087	7.195	0.4915	19.129	2.6586	218.87	20.66	3.96	7.8	2.0
26	835.00	1349.8	0.087	7.194	0.5294	19.138	2.6603	218.99	20.67	3.96	7.8	2.0
27	835.03	1349.8	0.087	7.194	0.5692	19.142	2.6608	219.03	20.67	3.96	7.8	2.0
28	834.64	1350.0	0.087	7.191	0.6069	19.193	2.6691	219.71	20.73	3.97	7.8	2.0
29	834.78	1350.1	0.087	7.192	0.6466	19.240	2.6753	220.22	20.78	3.97	7.8	2.0

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
AMD/SAT MAT PHASE I

TABLE A-5. MACH/FLOW-ANGULARITY PROBE MEASURED DATA (CONT'D)

DATE COMPUTED 20-JUL-81
TIME COMPUTED 13:22:51
DATE RECORDED 30-APR-81
TIME RECORDED 9: 3:57
PROJECT NUMBER C145VB

PAGE 2
RUN 218
M = 7.97
RE = 3.627E+06

ALPHA SECTOR= -8.01 DEG
ALPHAP = -20.01 DEG
MODEL-ROLL = 180.00 DEG

CONFIGURATION 10.5/7-DEG BICONIC/5S+DS
NOSE RADIUS,IN 0.5000
TRIP .06 MACHINED
FLAP NONE

DATA TYPE: 2, SURVEY-MACH/ FLOW ANGULARITY PROBE   SURVEY STATION NO = 39   PWX/PT= 1.109E-03

TEST CONDITIONS AND LOCAL CONDITIONS FROM P5 OF THE MACH/FLOW ANGULARITY PROBE

POINT	PT (PSIA)	TT (DEGR)	P (PSIA)	PT2 (PSIA)	ZM (IN)	P5 (PSIA)	P5/PT2	P5/P	P5/PWX	ML	TREC (SEC)	TDEL (SEC)
30	835.32	1350.1	0.087	7.196	0.6862	19.300	2.6820	220.77	20.83	3.97	7.8	2.0
31	835.39	1350.2	0.087	7.197	0.7256	19.341	2.6874	221.22	20.88	3.98	7.8	2.0
32	835.28	1350.3	0.087	7.196	0.7646	19.381	2.6933	221.70	20.92	3.98	7.8	2.0
33	835.07	1350.5	0.087	7.194	0.8031	19.493	2.7096	223.04	21.05	4.00	7.8	2.0
34	834.96	1350.6	0.087	7.193	0.8623	19.743	2.7446	225.93	21.32	4.02	7.8	2.0
35	834.85	1350.7	0.087	7.192	0.9712	20.213	2.8103	231.34	21.83	4.07	7.8	2.0
36	834.49	1350.9	0.087	7.189	1.0184	20.983	2.9195	240.25	22.67	4.15	7.8	2.0
37	834.51	1351.1	0.087	7.190	1.1172	21.824	3.0354	249.87	23.56	4.24	7.8	2.0
38	835.05	1351.1	0.087	7.194	1.2140	22.646	3.1478	259.12	24.45	4.31	7.8	2.0
39	834.99	1351.4	0.087	7.194	1.3112	23.487	3.2649	268.76	25.36	4.40	7.8	2.0
40	834.81	1351.5	0.087	7.192	1.4008	24.285	3.3766	277.96	26.23	4.47	7.8	2.0
41	833.74	1351.7	0.087	7.192	1.5065	24.375	3.3895	279.01	26.33	4.48	7.8	2.0
42	833.56	1351.9	0.087	7.190	1.6040	21.298	2.9622	243.85	23.01	4.18	7.8	2.0
43	834.44	1352.1	0.087	7.189	1.7022	6.007	0.8352	68.76	6.49	2.16	7.8	2.0
44	834.34	1352.2	0.087	7.188	1.7999	5.994	0.8338	68.64	6.48	2.15	7.8	2.0
45	834.28	1352.3	0.087	7.188	1.8968	5.998	0.8344	68.69	6.48	2.16	7.8	2.0
46	834.15	1352.4	0.087	7.187	1.9953	5.992	0.8337	68.63	6.48	2.15	7.8	2.0
47	834.10	1352.5	0.087	7.187	1.9954	5.988	0.8332	68.59	6.47	2.15	7.8	2.0

RUN 218

PT =	833.22	PSIA	V =	3882.0	FT/SEC
TT =	1352.8	DEGR	Q =	3.881	PSIA
P =	0.0872	PSIA	T =	98.6	DEGR
RE =	3.627E+06	PER FT	PT2 =	7.18	PSIA
MU =	7.937E-08	LBF-SEC/FT2	RHO =	2.386E-03	LBM/FT3
DEW=	-53.	DEG F	C.R.=	-0.05	IN

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
BMO/SAI MAT PHASE I

TABLE A-5. MACH/FLOW-ANGULARITY PROBE MEASURED DATA (CONT'D)

TIME COMPUTED 13:22:34
DATE RECORDED 30-APR-81
TIME RECORDED 9: 3:53
PROJECT NUMBER C145VH

PAGE 3
RUN 218
M = 7.97
RE = 3.627E+06

ALPHA SECTOR= -8.01 DEG
ALPHAP = -20.01 DEG
MODEL-ROLL = 180.00 DEG

CONFIGURATION 10.5/7-DEG BICONIC/SS+DS
NOSE RADIUS,IN 0.5000
TRIP .06 MACHINED
FLAP NONE

DATA TYPE: 2, SURVEY-MACH/FLOW ANGULARITY PROBE   SURVEY STATION NO = 39

POINT	P1 (PSIA)	P2 (PSIA)	P3 (PSIA)	P4 (PSIA)	P5 (PSIA)	P1/ P1F	P2/ P2F	P3/ P3F	P4/ P4F	P5/ P5F	PAVG/ P5	DPSQP	MLC	AATCA (DEG)	CPHI (DEG)	ALPT (DEG)	PAVGP5C
1	3.132	1.892	1.573	1.444	5.352	1.000	1.000	1.000	0.998	0.997	0.375	0.151	1.867	12.13	196.04	-19.90	0.335
2	3.215	2.117	1.406	1.589	7.121	1.000	1.000	0.998	1.004	0.999	0.292	0.132	2.241	11.19	196.27	-19.81	0.267
3	3.281	2.340	1.172	1.767	8.360	1.000	1.000	0.983	1.005	0.999	0.255	0.130	2.553	11.56	195.21	-19.80	0.237
4	3.385	2.449	1.042	1.856	9.357	0.999	1.000	0.986	1.002	0.999	0.233	0.129	2.815	11.88	194.19	-19.81	0.219
5	3.494	2.468	1.245	1.840	10.206	0.999	1.000	1.017	1.000	0.999	0.222	0.114	2.887	10.66	195.58	-19.69	0.210
6	3.601	2.540	1.263	1.818	11.099	1.000	1.000	1.001	0.999	0.999	0.208	0.110	3.095	10.57	197.15	-19.54	0.198
7	3.692	2.643	1.237	1.834	11.909	1.001	1.000	0.998	1.001	0.999	0.197	0.109	3.266	10.67	198.25	-19.47	0.190
8	3.775	2.763	1.276	1.867	12.737	1.000	1.000	1.002	1.001	0.999	0.190	0.104	3.386	10.44	199.72	-19.34	0.184
9	3.834	2.862	1.328	1.893	13.413	1.001	0.999	1.004	1.001	0.999	0.185	0.100	3.465	10.16	201.15	-19.26	0.180
10	3.862	2.906	1.352	1.905	13.699	0.999	0.999	1.001	1.000	0.998	0.183	0.099	3.494	10.05	201.77	-19.11	0.178
11	3.910	3.007	1.417	1.934	14.376	1.000	0.999	1.007	1.002	0.998	0.179	0.094	3.561	9.73	203.30	-19.15	0.175
12	3.945	3.082	1.477	1.955	14.845	0.999	0.999	1.007	1.001	0.999	0.176	0.091	3.597	9.47	204.54	-19.16	0.172
13	3.967	3.129	1.516	1.966	15.111	1.000	0.999	1.004	1.000	0.999	0.175	0.090	3.605	9.33	205.39	-19.33	0.172
14	4.012	3.186	1.566	1.984	15.412	1.000	1.000	1.004	1.001	1.000	0.174	0.088	3.606	9.70	206.16	-19.70	0.171
15	4.066	3.226	1.567	1.997	15.614	1.000	1.000	1.003	1.001	1.000	0.174	0.089	3.611	9.22	206.37	-19.79	0.171
16	4.132	3.253	1.598	2.011	15.795	1.000	1.000	1.001	1.001	1.000	0.174	0.049	3.618	9.31	206.22	-19.93	0.171
17	4.214	3.301	1.606	2.031	16.059	1.000	1.000	1.000	1.001	1.000	0.174	0.090	3.637	9.42	205.97	-19.96	0.171
18	4.320	3.356	1.620	2.066	16.460	1.000	1.000	1.001	1.002	1.000	0.173	0.091	3.668	9.52	205.55	-20.01	0.170
19	4.455	3.447	1.644	2.112	17.109	1.000	1.000	1.002	1.002	1.000	0.170	0.091	3.728	9.59	205.42	-20.04	0.168
20	4.568	3.550	1.676	2.154	17.822	1.001	1.000	1.003	1.002	1.000	0.168	0.090	3.799	9.60	205.77	-20.06	0.166
21	4.638	3.644	1.710	2.179	18.374	1.000	1.000	1.002	1.001	1.000	0.166	0.089	3.848	9.55	206.58	-20.06	0.164
22	4.711	3.732	1.752	2.204	18.825	0.999	1.001	1.002	1.001	1.000	0.165	0.088	3.868	9.52	207.32	-20.06	0.163
23	4.757	3.777	1.767	2.218	19.026	1.002	1.001	1.001	1.001	1.000	0.165	0.089	3.874	9.54	207.53	-20.07	0.163
24	4.791	3.802	1.768	2.227	19.103	1.000	1.000	1.000	1.000	1.000	0.165	0.089	3.872	9.69	207.50	-20.07	0.163
25	4.827	3.820	1.766	2.235	19.129	1.000	1.000	1.000	1.000	1.000	0.165	0.090	3.864	9.67	207.37	-20.06	0.164
26	4.856	3.843	1.764	2.232	19.138	0.999	0.999	1.000	1.000	1.000	0.166	0.091	3.856	9.76	207.51	-20.07	0.164
27	4.894	3.855	1.759	2.237	19.147	1.002	1.000	1.000	1.000	1.000	0.166	0.092	3.849	9.96	207.30	-20.07	0.165
28	4.928	3.878	1.750	2.239	19.193	1.001	1.000	1.000	1.000	1.000	0.167	0.093	3.852	9.96	207.28	-20.06	0.165
29	4.965	3.903	1.747	2.242	19.240	1.000	1.000	1.000	1.000	1.000	0.167	0.094	3.850	10.05	207.30	-20.05	0.166
30	4.996	3.927	1.748	2.246	19.300	1.000	1.000	1.000	1.000	1.000	0.167	0.095	3.849	10.12	207.36	-20.05	0.166

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
RMO/SAI MAT PHASE I

TABLE A-5. MACH/FLOW-ANGULARITY PROBE MEASURED DATA (CONT'D)

DATE COMPUTED 20-JUL-81
TIME COMPUTED 13:22:52
DATE RECORDED 30-APR-81
TIME RECORDED 9: 3:57
PROJECT NUMBER C145VB

PAGE 4

RUN 218 ALPHA SECTOR = -8.01 DEG
M = 7.97 ALPHAP = -20.01 DEG
RE = 3.627E+06 MODEL-POLL = 180.00 DEG

CONFIGURATION: 10.5/7-DEG BICONIC/S5+08
NOSE RADIUS,IN: 0.5000
TRIP: .06 MACHINED
FLAP: NONE

DATA TYPE: 2, SURVEY-MACH/FLOW ANGULARITY PROBE SURVEY STATION NO = 39

POINT	P1 (PSIA)	P2 (PSIA)	P3 (PSIA)	P4 (PSIA)	P5 (PSIA)	P1/ P1F	P2/ P2F	P3/ P3F	P4/ P4F	P5/ P5F	PAVG/ P5	DPSOP	MLC	AATCA (DEG)	CPHI (DEG)	ALPT (DEG)	PAVGP5C
31	5.006	3.954	1.752	2.246	19.341	0.999	1.000	1.000	1.000	1.000	0.168	0.095	3.846	10.14	207.69	-20.05	0.166
32	5.039	3.976	1.757	2.251	19.381	1.001	1.000	1.000	1.000	1.000	0.168	0.096	3.836	10.19	207.73	-20.04	0.167
33	5.082	4.014	1.759	2.260	19.493	1.000	1.000	1.000	1.001	1.000	0.168	0.096	3.838	10.26	207.82	-20.04	0.167
34	5.170	4.103	1.775	2.280	19.743	0.999	1.000	1.000	1.001	1.000	0.169	0.098	3.837	10.37	208.23	-20.03	0.167
35	5.254	4.263	1.831	2.306	20.213	0.999	1.000	1.002	1.001	1.000	0.169	0.098	3.824	10.36	209.76	-20.02	0.168
36	5.371	4.567	1.954	2.355	20.983	1.000	1.000	1.004	1.001	1.000	0.170	0.097	3.783	10.26	212.92	-20.03	0.169
37	5.504	4.872	2.094	2.424	21.824	1.000	1.000	1.004	1.002	1.000	0.171	0.096	3.741	10.12	215.67	-20.05	0.169
38	5.648	5.170	2.226	2.498	22.646	1.000	1.000	1.002	1.001	0.999	0.171	0.096	3.707	10.06	218.09	-20.07	0.170
39	5.786	5.499	2.366	2.517	23.487	1.000	0.999	1.002	1.001	1.000	0.172	0.096	3.675	10.04	220.80	-20.07	0.171
40	5.920	5.816	2.510	2.607	24.285	1.000	1.001	1.001	1.001	1.000	0.173	0.096	3.641	10.02	223.26	-20.06	0.173
41	5.981	5.920	2.561	2.628	24.376	1.000	1.000	1.000	1.000	1.000	0.175	0.097	3.597	10.06	223.90	-20.05	0.174
42	4.808	8.321	2.638	1.651	21.298	0.998	0.992	1.001	0.928	1.010	0.204	0.165	3.595	16.21	251.98	-20.03	0.203
43	4.170	1.018	0.471	0.711	6.005	0.999	0.824	0.498	0.724	1.002	0.765	0.309	4.792	28.71	184.74	-19.99	0.251
44	4.161	0.847	0.280	0.772	5.994	1.000	0.954	0.514	0.931	1.000	0.253	0.324	6.361	29.44	181.11	-20.03	0.246
45	4.157	0.831	0.238	0.783	5.998	1.001	0.969	0.601	0.983	0.999	0.251	0.327	6.900	29.39	180.73	-20.03	0.246
46	4.157	0.830	0.230	0.786	5.997	0.999	1.003	0.717	0.998	1.000	0.250	0.328	6.966	29.41	180.63	-20.04	0.246
47	4.157	0.842	0.297	0.785	5.988	1.001	0.993	0.926	0.998	1.001	0.254	0.322	6.135	29.43	180.85	-20.04	0.246

RUN 218

PT =	833.22	PSIA	V =	3882.0	FT/SEC
TT =	1352.8	DEGR	Q =	3.881	PSIA
P =	0.0872	PSIA	T =	98.6	DEGR
RE =	3.627E+06	PER FT	PT2 =	7.18	PSIA
MU =	7.937E-08	LBF-SEC/FT2	RHO =	2.386E-03	LBM/FT3
DEW=	-53.	DEG F	C.R.=	-0.05	IN

TABLE 4-5. MACH/FLOW-ANGULARITY PROBE MEASURED DATA (CONT'D)

DATE COMPUTED 20-JUL-81
TIME COMPUTED 13:22:53
DATE RECORDED 30-APR-81
TIME RECORDED 9: 3:57
PROJECT NUMBER C145VB

CONFIGURATION	NOSE RADIUS,IN	TRIP	FLAP
10.5/7-DEG BICONIC/SS+DS	0.5000	.06 MACHINED	NONE

= -4.01 DEG
= -20.01 DEG
= 180.00 DEG

MACH/FLOW ANGULARITY PROBE
STATISTICS

KNP(1-5) = 0.057 0.080 0.061 0.050 0.047
AP(1-5) = 0.100 0.100 0.100 0.100 0.100

POINT	TIME HR:MIN:SEC	P1I/ P1F	P2I/ P2F	P3I/ P3F	P4I/ P4F	P5I/ P5F	TNP1 (SEC)	TNP2 (SEC)	TNP3 (SEC)	TNP4 (SEC)	TNP5 (SEC)	KP1	KP2	KP3	KP4	KP5
1	9: 3:57	0.997	0.998	1.003	0.998	0.991	2.756	3.217	5.050	6.681	1.960	-0.003	0.027	0.016	-0.000	0.004
2	9: 4:49	0.999	0.995	1.011	0.992	0.994	2.686	2.883	5.637	6.121	1.482	0.007	0.034	0.037	0.047	0.019
3	9: 5: 9	0.999	0.992	1.041	0.986	0.997	2.635	2.615	6.597	5.531	1.261	0.014	0.051	0.051	0.046	0.021
4	9: 5:32	0.996	0.996	1.027	0.992	0.996	2.552	2.501	7.403	5.255	1.110	0.006	0.048	0.070	0.042	0.009
5	9: 5:53	0.997	0.999	0.960	1.002	0.996	2.472	2.482	6.433	5.288	1.036	0.022	0.016	0.052	0.029	-0.000
6	9: 6:15	0.999	0.996	0.999	1.001	0.998	2.403	2.412	6.250	5.349	0.953	0.004	0.038	0.095	0.045	-0.007
7	9: 6:32	0.997	0.994	1.005	0.999	0.997	2.345	2.320	6.353	5.311	0.888	0.017	0.045	0.028	0.026	-0.004
8	9: 6:55	0.999	0.996	0.996	0.997	0.998	2.292	2.222	6.193	5.223	0.832	-0.003	0.049	0.151	0.074	0.003
9	9: 7:13	1.002	0.997	0.963	0.997	0.997	2.260	2.145	5.972	5.152	0.789	-0.000	0.031	-0.051	0.042	0.005
10	9: 8:15	0.996	0.996	0.996	0.998	0.995	2.241	2.112	5.852	5.116	0.772	-0.001	-0.002	0.011	-0.012	0.000
11	9: 8:26	0.996	0.988	0.976	0.993	0.994	2.216	2.043	5.624	5.050	0.736	0.044	0.048	0.047	0.054	0.005
12	9: 8:38	0.996	0.992	0.976	0.994	0.996	2.194	1.994	5.403	4.995	0.713	0.034	0.048	0.050	0.059	0.008
13	9: 8:50	0.997	0.995	0.985	0.997	0.998	2.183	1.965	5.254	4.963	0.701	0.015	0.043	0.040	-0.006	0.001
14	9: 9: 2	0.996	0.995	0.983	0.995	0.998	2.159	1.931	5.095	4.921	0.688	0.020	0.056	0.054	0.031	0.016
15	9: 9:14	0.996	0.996	0.993	0.997	0.999	2.130	1.908	5.019	4.890	0.679	0.030	0.054	0.049	0.034	0.005
16	9: 9:26	0.994	0.998	0.996	0.997	1.000	2.097	1.889	4.980	4.858	0.672	0.023	0.073	0.075	0.063	-0.003
17	9: 9:37	0.994	0.997	0.997	0.996	0.999	2.057	1.865	4.951	4.810	0.660	0.065	0.069	0.027	0.058	0.001
18	9: 9:50	0.994	0.996	0.996	0.993	0.999	2.008	1.834	4.914	4.736	0.644	0.029	0.052	0.048	0.049	0.002
19	9: 10: 2	0.994	0.994	0.993	0.991	0.999	1.947	1.787	4.847	4.636	0.620	0.050	0.065	0.063	0.043	0.005
20	9: 10:25	0.997	0.994	0.991	0.992	0.999	1.901	1.736	4.761	4.546	0.595	0.026	0.041	0.084	0.064	0.018
21	9: 10:37	0.997	0.995	0.990	0.994	0.999	1.871	1.692	4.668	4.491	0.577	0.015	0.030	0.050	0.040	0.006
22	9: 10:50	0.996	0.997	0.989	0.996	0.999	1.841	1.653	4.558	4.442	0.563	0.007	0.057	0.041	0.057	0.001
23	9: 11: 3	1.001	1.000	0.996	0.998	1.000	1.828	1.634	4.516	4.411	0.558	0.024	0.005	0.080	0.089	0.001
24	9: 11:15	1.000	0.998	1.000	0.999	1.000	1.811	1.623	4.509	4.393	0.556	-0.001	0.048	-0.014	0.050	0.011
25	9: 11:28	0.999	0.998	1.001	0.999	1.000	1.798	1.615	4.514	4.379	0.555	0.002	0.004	-0.036	0.035	0.000
26	9: 11:40	0.999	0.998	1.001	1.000	1.000	1.787	1.604	4.519	4.380	0.554	0.008	0.014	0.070	0.013	0.001
27	9: 11:53	0.999	0.999	1.001	0.999	1.000	1.777	1.600	4.532	4.374	0.554	0.036	0.000	-0.019	-0.010	0.000
28	9: 12: 5	0.999	0.998	1.002	1.000	1.000	1.763	1.592	4.552	4.370	0.553	0.035	0.051	0.045	0.023	-0.002
29	9: 12:18	0.999	0.997	1.001	0.999	0.999	1.749	1.581	4.560	4.361	0.551	0.004	0.040	0.024	0.001	-0.001

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
RHO/SAI MAT PHASE I

TABLE A-5. MACH/FLOW-ANGULARITY PROBE MEASURED DATA (CONT'D)

DATE COMPUTED 20-[illegible]-81
TIME COMPUTED 13:22:54
DATE RECORDED 30-APR-81
TIME RECORDED 9: 3:57
PROJECT NUMBER C145VB

PAGE 6
RUN 218
M = 7.97
RE = 3.627E+06

ALPHA SECTOR = -8.01 DEG
ALPHAP = -20.01 DEG
MODEL-ROLL = 180.00 DEG

CONFIGURATION: 10.5/7-DEG BICONIC/SS+DS
NOSE RADIUS,IN: 0.5000
TRIP: .06 MACHINED
FLAP: NONE

DATA TYPE: 2, SURVEY-MACH/FLOW ANGULARITY PROBE
PRESSURE STABILIZATION STATISTICS

KNP(1-5) = 0.057 0.080 0.061 0.050 0.047
AP(1-5) = 0.100 0.100 0.100 0.100 0.100

POINT	TIME HR:MIN:SEC	P1I/ P1F	P2I/ P2F	P3I/ P3F	P4I/ P4F	P5I/ P5F	TNP1 (SEC)	TNP2 (SEC)	TNP3 (SEC)	TNP4 (SEC)	TNP5 (SEC)	KP1	KP2	KP3	KP4	KP5
30	9: 12:30	0.999	0.998	1.000	1.000	1.000	1.738	1.571	4.559	4.357	0.550	-0.003	-0.003	0.014	-0.011	0.003
31	9: 12:43	1.001	0.998	0.999	1.000	1.000	1.734	1.561	4.550	4.356	0.549	0.013	0.037	0.071	0.003	0.002
32	9: 12:55	1.000	0.998	0.998	0.999	1.000	1.725	1.552	4.535	4.346	0.548	0.003	0.043	-0.011	0.048	-0.003
33	9: 13: 8	0.999	0.999	1.000	0.998	1.000	1.709	1.539	4.533	4.331	0.545	0.013	0.020	0.021	0.066	0.026
34	9: 13:21	0.999	0.996	0.996	0.998	1.000	1.679	1.505	4.494	4.294	0.537	0.004	0.035	0.046	0.055	-0.001
35	9: 13:31	0.998	0.996	0.986	0.996	1.000	1.653	1.449	4.368	4.247	0.525	0.009	0.039	0.058	0.050	0.001
36	9: 13:48	1.000	0.995	0.978	0.994	1.000	1.619	1.354	4.107	4.162	0.506	0.005	0.042	0.058	0.061	-0.001
37	9: 14: 3	0.998	0.994	0.976	0.992	0.999	1.579	1.270	3.838	4.050	0.486	0.016	0.050	0.061	0.060	0.004
38	9: 14:17	0.998	0.995	0.980	0.993	0.999	1.539	1.197	3.609	3.944	0.468	0.002	0.036	0.055	0.052	-0.007
39	9: 14:31	0.998	0.997	0.981	0.994	1.000	1.502	1.126	3.400	3.855	0.452	-0.004	0.018	0.062	0.074	-0.009
40	9: 14:45	0.999	0.997	0.983	0.993	1.000	1.470	1.066	3.206	3.766	0.437	0.000	0.043	0.049	0.044	0.001
41	9: 15: 0	0.999	1.001	0.996	0.999	1.000	1.455	1.047	3.141	3.736	0.435	0.001	-0.004	0.051	0.062	-0.003
42	9: 15:14	1.033	0.967	0.987	1.216	1.027	1.802	0.741	3.052	5.468	0.503	0.067	0.022	0.052	0.058	0.002
43	9: 15:29	1.006	1.913	1.679	1.302	1.091	2.077	4.864	8.219	9.693	1.760	0.038	0.066	0.056	0.060	0.041
44	9: 15:43	1.001	1.112	1.296	1.066	1.000	2.083	6.669	13.764	11.384	1.759	-0.000	0.043	0.055	0.056	-0.006
45	9: 15:57	1.001	1.011	1.173	1.015	0.998	2.088	7.005	18.461	11.820	1.758	-0.002	0.051	0.057	0.067	0.026
46	9: 16:12	1.000	0.996	1.105	1.002	1.000	2.083	7.125	22.124	11.930	1.760	0.007	-0.066	0.039	-0.100	0.003
47	9: 16:27	1.001	0.961	0.923	1.002	1.002	2.088	6.959	22.124	11.960	1.763	0.010	0.321	1.407	-0.014	0.001

RUN 218

PT =	833.22	PSIA	V =	3882.0	FT/SEC
TT =	1352.8	DEGR	Q =	3.681	PSIA
P =	0.0872	PSIA	T =	98.6	DEGR
RE =	3.627E+06	PER FT	PT2 =	7.18	PSIA
MU =	7.937E-08	LBF-SEC/FT2	RHO =	2.386E-03	LBM/FT3
DEW=	-53.	DEG F	C.R.=	-0.05	IN

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
BMO/SAI MAT PHASE I

TABLE A-5. MACH/FLOW-ANGULARITY PROBE MEASURED DATA (CONT'D)

DATE COMPUTED 20-JUL-81
TIME COMPUTED 13:22:54
DATE RECORDED 30-APR-81
TIME RECORDED 91 3:57
PROJECT NUMBER C145VB

PAGE 7		CONFIGURATION	NOSE RADIUS,IN	TRIP	FLAP
RUN 218	ALPHA SECTOR= -8.01 DEG	10.5/7-DEG BICONIC/SS+DS	0.5000	.06 MACHINED	NONE
M = 7.97	ALPHAP = -20.01 DEG				
RE = 3.627E+06	MODEL-ROLL = 180.00 DEG				

DATA TYPE : 2, SURVEY-MACH/FLOW ANGULARITY PROBE
MODEL SURFACE TEMPERATURES

POINT	TG 1 TG 2 DEGR	TG 3 TG 4 DEGR	TG 5 TG 6 DEGR	TG 7 TG 8 DEGR	TG 9 TG 10 DEGR	TG 11 TG 12 DEGR	TG 13 TG 14 DEGR	TG 15 TG 16 DEGR	TG102 TG104 DEGR	TG106 TG108 DEGR	TG110 TG112 DEGR	TG114 TG116 DEGR	TG118 TG120 DEGR	TG122 DEGR
1		1193.	1133.	1159.	1084.							1227.		
	1209.	1186.				1018.			1232.	1222.			1232.	
2		1193.	1133.	1160.	1083.							1228.		
	1210.	1186.				1018.			1232.	1223.			1231.	
3		1194.	1133.	1160.	1083.							1228.		
	1210.	1186.				1018.			1232.	1224.			1232.	
4		1194.	1133.	1160.	1083.							1228.		
	1210.	1186.				1017.			1232.	1224.			1231.	
5		1193.	1134.	1160.	1083.							1227.		
	1209.	1186.				1017.			1231.	1223.			1231.	
6		1193.	1134.	1160.	1083.							1227.		
	1209.	1186.				1017.			1231.	1223.			1231.	
7		1193.	1134.	1160.	1083.							1227.		
	1209.	1186.				1017.			1231.	1223.			1231.	
8		1193.	1134.	1160.	1083.							1227.		
	1209.	1186.				1017.			1231.	1222.			1231.	
9		1193.	1134.	1160.	1082.							1227.		
	1209.	1186.				1017.			1231.	1223.			1231.	
10		1194.	1134.	1160.	1082.							1227.		
	1209.	1186.				1017.			1231.	1224.			1231.	
11		1193.	1134.	1160.	1082.							1226.		
	1209.	1186.				1017.			1230.	1221.			1230.	
12		1194.	1134.	1160.	1082.							1227.		
	1209.	1186.				1017.			1231.	1223.			1231.	
13		1193.	1134.	1160.	1082.							1227.		
	1209.	1186.				1017.			1231.	1223.			1230.	
14		1193.	1134.	1160.	1082.							1226.		
	1209.	1186.				1017.			1230.	1222.			1230.	
15		1193.	1134.	1160.	1082.							1226.		
	1209.	1186.				1017.			1230.	1222.			1230.	
16		1193.	1134.	1160.	1082.							1226.		
	1209.	1186.				1017.			1230.	1222.			1230.	
17		1193.	1134.	1160.	1082.							1226.		
	1209.	1186.				1017.			1230.	1222.			1230.	

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
BMO/SAT MAT PHASE I

TABLE A-5. MACH/FLOW-ANGULARITY PROBE MEASURED DATA (CONT'D)

DATE COMPUTED 20-JUL-81
TIME COMPUTED 13:22:55
DATE RECORDED 30-APR-81
TIME RECORDED 9: 3:57
PROJECT NUMBER C145VB

PAGE 8		CONFIGURATION	NOSE RADIUS,IN	TRIP	FLAP
RUN 218	ALPHA SECTOR= -8.01 DEG	10.5/7-DEG BICONIC/SS+DS	0.5000	.06 MACHINED	NONE
M = 7.97	ALPHAP = -20.01 DEG				
RE = 3.677E+06	MODEL-ROLL = 180.00 DEG				

DATA TYPE : 2, SURVEY-MACH/FLOW ANGULARITY PROBE
MODEL SURFACE TEMPERATURES

POINT	TG 1 / TG 2 DEGR	TG 3 / TG 4 DEGR	TG 5 / TG 6 DEGR	TG 7 / TG 8 DEGR	TG 9 / TG 10 DEGR	TG 11 / TG 12 DEGR	TG 13 / TG 14 DEGR	TG 15 / TG 16 DEGR	TG102 / TG104 DEGR	TG106 / TG108 DEGR	TG110 / TG112 DEGR	TG114 / TG116 DEGR	TG118 / TG120 DEGR	TG122 DEGR
18		1193.	1134.	1160.	1081.							1227.		
	1209.	1186.				1016.			1231.	1223.			1230.	
19		1193.	1134.	1160.	1081.							1227.		
	1209.	1186.				1016.			1231.	1224.			1230.	
20		1193.	1134.	1160.	1081.							1227.		
	1209.	1186.				1016.			1231.	1225.			1230.	
21		1192.	1134.	1160.	1081.							1225.		
	1208.	1186.				1016.			1229.	1221.			1229.	
22		1193.	1134.	1160.	1081.							1226.		
	1209.	1185.				1017.			1230.	1223.			1230.	
23		1194.	1134.	1160.	1081.							1227.		
	1208.	1186.				1016.			1231.	1225.			1231.	
24		1193.	1134.	1160.	1081.							1226.		
	1209.	1185.				1016.			1230.	1223.			1230.	
25		1194.	1134.	1160.	1081.							1227.		
	1208.	1186.				1016.			1231.	1224.			1230.	
26		1193.	1135.	1160.	1081.							1226.		
	1208.	1185.				1016.			1230.	1223.			1230.	
27		1192.	1135.	1160.	1081.							1225.		
	1208.	1185.				1016.			1229.	1221.			1229.	
28		1194.	1135.	1160.	1081.							1227.		
	1208.	1185.				1016.			1231.	1224.			1230.	
29		1193.	1135.	1160.	1081.							1226.		
	1208.	1185.				1016.			1230.	1222.			1230.	
30		1192.	1135.	1160.	1081.							1225.		
	1208.	1185.				1016.			1228.	1220.			1229.	
31		1192.	1135.	1160.	1081.							1225.		
	1208.	1185.				1016.			1229.	1221.			1229.	
32		1192.	1135.	1160.	1081.							1226.		
	1208.	1185.				1016.			1230.	1222.			1229.	
33		1194.	1135.	1159.	1081.							1226.		
	1208.	1185.				1016.			1230.	1222.			1230.	
34		1192.	1135.	1159.	1081.							1225.		
	1208.	1185.				1016.			1230.	1222.			1229.	

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
RHO/SAT MAT PHASE I

TABLE A-5. MACH/FLOW-ANGULARITY PROBE MEASURED DATA (CONT'D)

TIME COMPUTED 13:22:57
DATE RECORDED 30-APR-81
TIME RECORDED 9: 3:57
PROJECT NUMBER C145VB

PAGE 9
RUN 218
M = 7.97
RE = 3.627E+06

ALPHA SECTOR= -8.01 DEG
ALPHAP = -20.01 DEG
MODEL-ROLL = 180.00 DEG

CONFIGURATION 10.5/7-DEG BICONIC/SS+DS
NOSE RADIUS,IN 0.5000
TRIP .06 MACHINED
FLAP NONE

DATA TYPE : 2, SURVEY-MACH/FLOW ANGULARITY PROBE
MODEL SURFACE TEMPERATURES

POINT	TG 1 TG 2 DEGR	TG 3 TG 4 DEGR	TG 5 TG 6 DEGR	TG 7 TG 8 DEGR	TG 9 TG 10 DEGR	TG 11 TG 12 DEGR	TG 13 TG 14 DEGR	TG 15 TG 16 DEGR	TG102 TG104 DEGR	TG106 TG108 DEGR	TG110 TG112 DEGR	TG114 TG116 DEGR	TG118 TG120 DEGR	TG122 DEGR
35		1193.	1135.	1159.	1080.							1226.		
	1208.	1185.				1016.			1229.	1222.			1229.	
36		1193.	1135.	1159.	1080.							1226.		
	1208.	1185.				1016.			1230.	1223.			1230.	
37		1193.	1135.	1158.	1077.							1226.		
	1209.	1185.				1014.			1231.	1224.			1230.	
38		1192.	1135.	1160.	1080.							1225.		
	1208.	1185.				1016.			1229.	1220.			1229.	
39		1193.	1135.	1159.	1080.							1226.		
	1209.	1185.				1016.			1230.	1222.			1230.	
40		1193.	1135.	1159.	1080.							1226.		
	1209.	1185.				1016.			1230.	1223.			1230.	
41		1193.	1135.	1159.	1080.							1226.		
	1209.	1185.				1016.			1229.	1221.			1230.	
42		1192.	1135.	1160.	1080.							1226.		
	1209.	1186.				1016.			1230.	1222.			1230.	
43		1194.	1135.	1160.	1080.							1227.		
	1209.	1186.				1016.			1232.	1225.			1231.	
44		1194.	1135.	1160.	1080.							1227.		
	1209.	1186.				1016.			1232.	1225.			1231.	
45		1194.	1135.	1160.	1080.							1227.		
	1209.	1186.				1016.			1232.	1225.			1231.	
46		1194.	1135.	1160.	1080.							1227.		
	1209.	1186.				1016.			1231.	1224.			1231.	
47		1193.	1135.	1160.	1080.							1227.		
	1209.	1186.				1016.			1231.	1224.			1231.	

RUN 218

PT =	833.22	PSIA		V =	3882.0	FT/SEC
TT =	1352.8	DEGR		Q =	3.881	PSIA
P =	0.0872	PSIA		T =	98.6	DEGR
RE =	3.627E+06	PER FT		PT2 =	7.18	PSIA
MU =	7.937E-08	LBF-SEC/FT2		RHO =	2.386E-03	LBM/FT3
DEW=	-53.	DEG F		C.R.=	-0.05	IN

ARVIN/CALSPAN FIELD SERVICES, INC.
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VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
BMO/SAI MAT PHASE I

TABLE A-6. MACH/FLOW-ANGULARITY DERIVED DIRECTIONAL DATA

PROJECT NUMBER C145VB

PAGE 1
RUN 218 ALPHA SECTOR= -8.01 DEG
M = 7.97 ALPHAP = -20.01 DEG
RE = 3.627E+06 MODEL-ROLL = 180.00 DEG

CONFIGURATION: 10.5/7-DEG BICONIC/SS+DS
NOSE RADIUS,IN: 0.5000
TRIP: .06 MACHINED
FLAP: NONE

DATA TYPE: 2, SURVEY-MACH/FLOW ANGULARITY PROBE SURVEY STATION NO = 39 PWX/PT= 0.111E-02

VELOCITY VECTORS THETAO=-29.00 DEG PSIO= 3.30 DEG PHIO= -5.00 DEG

POINT	MLC	AATCA (DEG)	CPHI (DEG)	UP/VL	VP/VL	WP/VL	UF/VL	VF/VL	WF/VL	UM/VL	VM/VL	WM/VL
1	1.87	12.13	196.04	0.9777	-0.0581	-0.2020	0.9526	-0.0190	0.3037	0.9990	-0.0190	-0.0405
2	2.24	11.19	196.27	0.9810	-0.0543	-0.1862	0.9478	-0.0138	0.3187	0.9996	-0.0138	-0.0248
3	2.55	11.56	195.21	0.9797	-0.0526	-0.1933	0.9501	-0.0127	0.3117	0.9994	-0.0127	-0.0322
4	2.81	11.88	194.19	0.9786	-0.0505	-0.1995	0.9521	-0.0112	0.3055	0.9992	-0.0112	-0.0386
5	2.89	10.66	195.58	0.9828	-0.0497	-0.1781	0.9453	-0.0083	0.3261	0.9998	-0.0083	-0.0170
6	3.08	10.57	197.15	0.9830	-0.0541	-0.1753	0.9442	-0.0125	0.3291	0.9998	-0.0125	-0.0138
7	3.27	10.67	198.25	0.9827	-0.0580	-0.1759	0.9442	-0.0164	0.3289	0.9998	-0.0164	-0.0140
8	3.39	10.44	199.72	0.9835	-0.0611	-0.1705	0.9423	-0.0190	0.3342	0.9998	-0.0190	-0.0083
9	3.47	10.16	201.15	0.9843	-0.0636	-0.1645	0.9401	-0.0209	0.3402	0.9998	-0.0209	-0.0020
10	3.49	10.05	201.77	0.9847	-0.0647	-0.1620	0.9392	-0.0218	0.3425	0.9998	-0.0218	0.0005
11	3.56	9.73	203.30	0.9856	-0.0668	-0.1552	0.9368	-0.0232	0.3492	0.9997	-0.0232	0.0076
12	3.59	9.47	204.54	0.9864	-0.0684	-0.1497	0.9348	-0.0242	0.3544	0.9996	-0.0242	0.0132
13	3.60	9.33	205.39	0.9868	-0.0695	-0.1465	0.9335	-0.0251	0.3576	0.9995	-0.0251	0.0166
14	3.61	9.20	206.16	0.9871	-0.0705	-0.1435	0.9324	-0.0258	0.3604	0.9995	-0.0258	0.0197
15	3.61	9.22	206.37	0.9871	-0.0712	-0.1436	0.9324	-0.0265	0.3604	0.9995	-0.0265	0.0197
16	3.62	9.31	206.22	0.9868	-0.0715	-0.1452	0.9330	-0.0269	0.3589	0.9995	-0.0269	0.0181
17	3.64	9.42	205.97	0.9865	-0.0717	-0.1472	0.9337	-0.0273	0.3571	0.9995	-0.0273	0.0161
18	3.67	9.52	205.55	0.9862	-0.0713	-0.1492	0.9344	-0.0271	0.3551	0.9995	-0.0271	0.0140
19	3.73	9.59	205.42	0.9860	-0.0715	-0.1505	0.9349	-0.0275	0.3539	0.9995	-0.0275	0.0127
20	3.80	9.60	205.77	0.9860	-0.0725	-0.1501	0.9347	-0.0284	0.3543	0.9995	-0.0284	0.0132
21	3.85	9.55	206.58	0.9861	-0.0743	-0.1485	0.9340	-0.0300	0.3560	0.9994	-0.0300	0.0150
22	3.87	9.52	207.32	0.9862	-0.0759	-0.1469	0.9333	-0.0315	0.3576	0.9994	-0.0315	0.0167
23	3.87	9.54	207.53	0.9862	-0.0766	-0.1469	0.9333	-0.0322	0.3576	0.9993	-0.0322	0.0167
24	3.87	9.60	207.50	0.9860	-0.0770	-0.1479	0.9336	-0.0327	0.3567	0.9993	-0.0327	0.0158
25	3.86	9.67	207.37	0.9858	-0.0773	-0.1492	0.9341	-0.0331	0.3555	0.9993	-0.0331	0.0145
26	3.86	9.76	207.51	0.9855	-0.0783	-0.1504	0.9344	-0.0343	0.3545	0.9993	-0.0343	0.0134
27	3.85	9.86	207.20	0.9852	-0.0785	-0.1522	0.9350	-0.0346	0.3528	0.9993	-0.0346	0.0116
28	3.85	9.96	207.[illegible]	0.9849	-0.0793	-0.1538	0.9356	-0.0356	0.3514	0.9993	-0.0356	0.0101
29	3.85	10.05	[illegible]	0.9846	-0.0801	-0.1551	0.9360	-0.0364	0.3501	0.9993	-0.0364	0.0088
30	3.85	10.12	207.36	0.9844	-0.0808	-0.1560	0.9363	-0.0372	0.3493	0.9993	-0.0372	0.0079
31	3.85	10.14	207.69	0.9844	-0.0818	-0.1558	0.9361	-0.0382	0.3496	0.9992	-0.0382	0.0082
32	3.84	10.19	207.73	0.9842	-0.0823	-0.1566	0.9364	-0.0388	0.3489	0.9992	-0.0388	0.0075
33	3.84	10.26	207.82	0.9840	-0.0831	-0.1576	0.9367	-0.0398	0.3480	0.9992	-0.0398	0.0065
34	3.83	10.37	208.23	0.9837	-0.0852	-0.1587	0.9369	-0.0419	0.3471	0.9991	-0.0419	0.0056
35	3.82	10.36	209.76	0.9837	-0.0892	-0.1561	0.9357	-0.0457	0.3498	0.9989	-0.0457	0.0085
36	3.78	10.26	212.92	0.9840	-0.0968	-0.1495	0.9328	-0.0526	0.3565	0.9985	-0.0526	0.0158
37	3.74	10.12	215.67	0.9844	-0.1025	-0.1428	0.9300	-0.0577	0.3631	0.9981	-0.0577	0.0230
38	3.71	10.06	218.09	0.9846	-0.1078	-0.1375	0.9276	-0.0625	0.3683	0.9976	-0.0625	0.0287
39	3.68	10.04	220.80	0.9847	-0.1139	-0.1320	0.9250	-0.0681	0.3738	0.9971	-0.0681	0.0347
40	3.64	10.02	223.26	0.9847	-0.1192	-0.1267	0.9225	-0.0729	0.3789	0.9965	-0.0729	0.0404

TABLE A-6. MACH/FLOW-ANGULARITY DERIVED DIRECTIONAL DATA (CONT'D)

AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
RMO/SAI MAT PHASE I

PROJECT NUMBER C145VB

			CONFIGURATION	NOSE RADIUS,IN	TRIP	FLAP
PAGE 2	ALPHA SECTOR= -8.01 DEG		10.5/7-DEG BICONIC/SS+DS	0.5000	.06 MACHINED	NONE
RUN 218	ALPHAP = -20.01 DEG					
M = 7.97	MODEL-ROLL = 180.00 DEG					
RE = 3.627E+06						

DATA TYPE: 2, SURVEY-MACH/FLOW ANGULARITY PROBE SURVEY STATION NO = 39 PWX/PT= 0.111E-02

VELOCITY VECTORS THETAO=-29.00 DEG PSIO= 3.30 DEG PHIO= -5.00 DEG

POINT	MLC	AATCA (DEG)	CPHI (DEG)	UP/VL	VP/VL	WP/VL	UF/VL	VF/VL	WF/VL	UM/VL	VM/VL	WM/VL
41	3.60	10.06	223.90	0.9846	-0.1211	-0.1258	0.9220	-0.0747	0.3798	0.9963	-0.0747	0.0415
42	3.60	16.21	251.98	0.9603	-0.2654	-0.0863	0.8826	-0.2162	0.4174	0.9722	-0.2162	0.0902
43	4.79	28.71	184.74	0.8771	-0.0397	-0.4787	0.9994	-0.0307	0.0127	0.9435	-0.0307	-0.3300
44	6.36	29.43	181.11	0.8709	-0.0095	-0.4914	1.0000	-0.0021	-0.0044	0.9381	-0.0021	-0.3463
45	6.90	29.39	180.73	0.8713	-0.0063	-0.4907	1.0000	0.0012	-0.0039	0.9383	0.0012	-0.3458
46	6.97	29.41	180.63	0.8711	-0.0054	-0.4911	1.0000	0.0020	-0.0045	0.9381	0.0020	-0.3463
47	6.13	29.43	180.85	0.8710	-0.0073	-0.4913	1.0000	0.0002	-0.0045	0.9381	0.0002	-0.3464

RUN 218

PT =	833.72	PSIA	V =	3882.0	FT/SEC
TT =	1352.8	DEGR	Q =	3.881	PSIA
P =	0.0872	PSIA	T =	98.6	DEGR
RE =	3.627E+06	PER FT	PT2 =	7.18	PSIA
MU =	7.937E-08	LBF-SEC/FT2	RHO =	2.386E-03	LBM/FT3
DEW=	-53.	DEG F	C.R.=	-0.05	IN

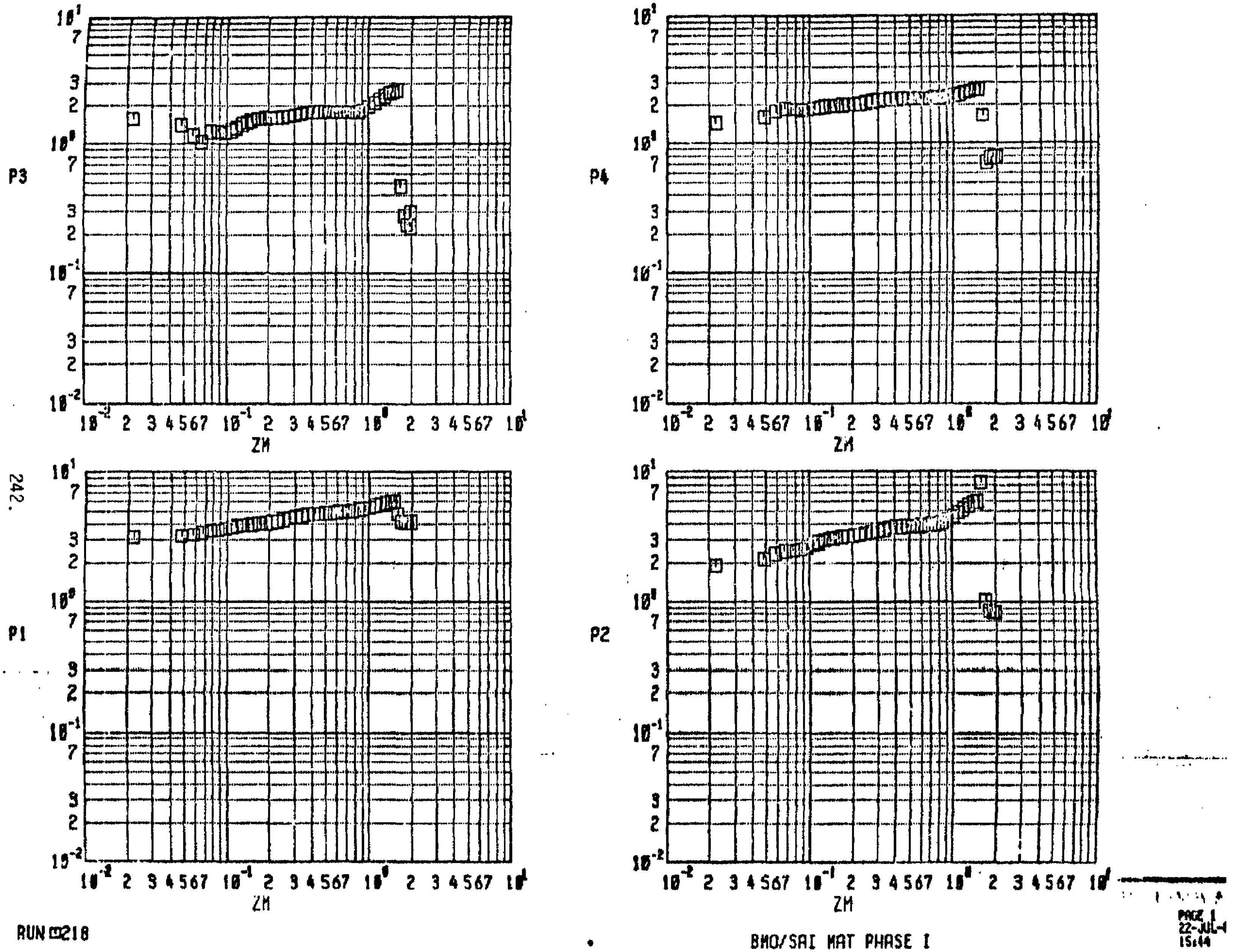

FIGURE A-19. MACH/FLOW-ANGULARITY PROBE PRESSURE DATA

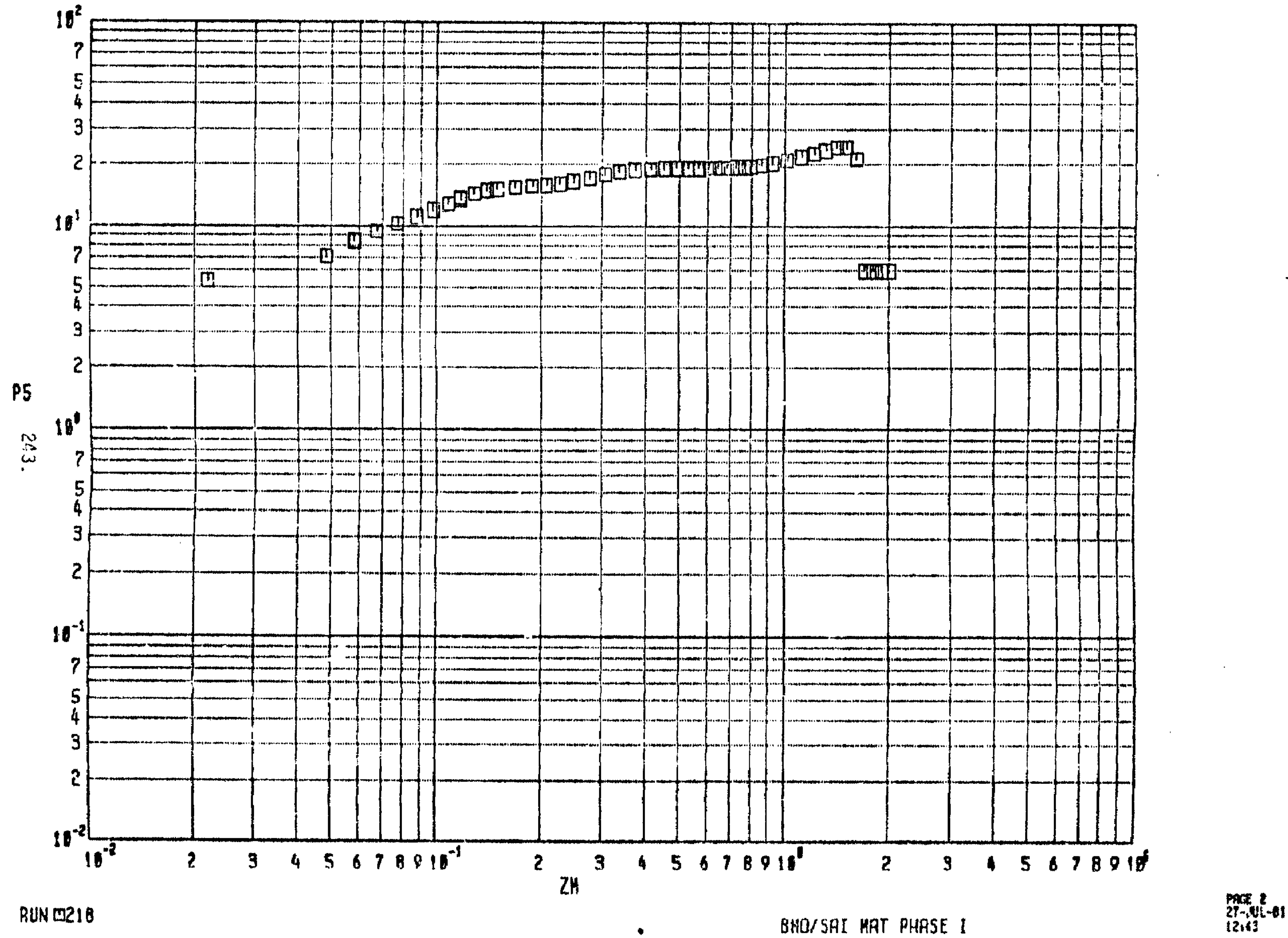

FIGURE A-19. MACH/FLOW-ANGULARITY PROBE PRESSURE DATA (CONT'D)

The aerodynamic force and moment coefficients are presented in the body and wind axes. The wind axes lift and drag coefficients (CLW and CDW, respectively) were calculated using the forebody axial-force coefficient (CA). The wind axes pitching- and rolling-moment coefficients (CLMW and CLLW, respectively) were calculated using the forebody pitching-moment coefficient (CLMF). Pitching- and yawing-moment coefficients are referenced to the virtual model nose. Biconic virtual model length (LM) and unsliced base area (A) were used as the reference length and area for the aerodynamic coefficients. Total axial-force coefficients (CAT) were corrected for base axial-force effects.

Pitching and yawing moment coefficients are referenced to the model base. Model base diameter (9.823 inches) and base area (75.784 inches^2) were used as the reference length and area for the model aerodynamic coefficients.

Representative tabular data for a static force α sweep is shown in Table A-7 (4 pages).

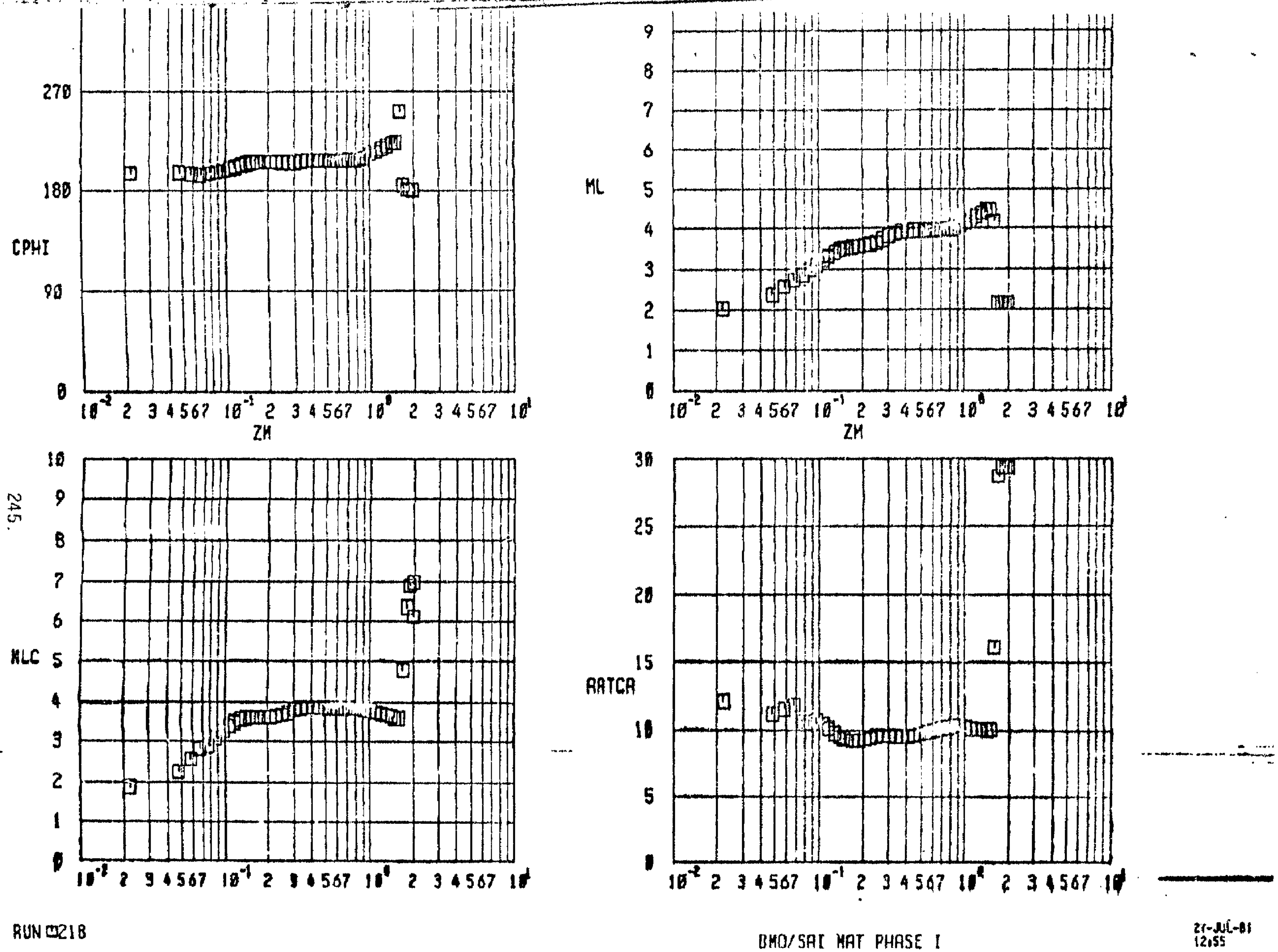

Figure A-20. Mach/Flow-Angularity Derived Directional Data

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PAGE 1

DATE COMPUTED 27-JUL-81
TIME COMPUTED 09:49:13
DATE RECORDED 20-JUL-81
TIME RECORDED 10: 5:39
PROJECT NUMBER V43B-21

TABLE A-7. FORCE AND MOMENT DATA

RUN	CODE	M	PT	TT	Q	P	T	RE	A	REF LENGTHS(CLP,CLN,CLL)		
17	7	7.97	826.46	1352.7	3.851	0.087	96.6	0.360E+07	75.784	33.258	33.258	33.258

CONFIG	RNOSE	SLICES	FLAP	TRIP
10.5/7 BICONIC	0.5	DOUBLE	10	60M

---TUNNEL CONDITIONS AND BASE PRESSURES---

PN	ALPI	PHII	PTM	PT	TT	Q	P	CAB	PB1/P	PB2/P	PB3/P	PB4/P	PBA/P	CPBA
1	11.87	0.09	845.8?	826.46	1352.7	3.851	0.087	0.0139						
[illegible]	10.87	0.09	845.96	826.54	1352.7	3.851	0.087	0.0151						
[illegible]	9.87	0.09	846.30	826.88	1352.7	3.853	0.087	0.0159						
4	8.87	0.0[illegible]	846.23	826.81	1352.7	3.852	0.087	0.0165						
5	7.87	[illegible]	[illegible]	826.74	1352.7	3.852	0.087	0.0169						
6	6.88	[illegible]	[illegible]	826.72	1352.7	3.852	0.087	0.0172						
7	5.88	0.09	846.22	826.80	1352.7	3.852	0.087	0.0174						
8	4.89	0.09	846.12	826.70	1352.7	3.852	0.087	0.0175						
9	3.89	0.09	846.09	826.67	1352.7	3.852	0.087	0.0175						
10	2.90	0.10	845.96	826.55	1352.7	3.851	0.087	0.0176						
11	1.91	0.09	846.19	826.76	1352.7	3.852	0.087	0.0176						
12	0.92	0.10	846.11	826.69	1352.7	3.852	0.087	0.0176						
13	-0.08	0.11	846.12	826.70	1352.7	3.852	0.087	0.0176						
14	-1.07	0.10	845.74	826.32	1352.7	3.850	0.087	0.0176						
15	-2.06	0.10	845.89	826.47	1352.7	3.851	0.087	0.0176						
16	-3.05	0.10	845.88	826.46	1352.7	3.851	0.087	0.0175						
17	-4.05	0.11	845.86	826.44	1352.7	3.851	0.087	0.0175						
18	-5.04	0.11	845.93	826.52	1352.7	3.851	0.087	0.0174						
19	-6.03	0.11	845.81	826.40	1352.7	3.851	0.087	0.0173						
20	-6.53	0.11	845.83	826.42	1352.7	3.851	0.087	0.0172						
21	-7.02	0.11	845.81	826.39	1352.7	3.850	0.087	0.0172						
22	-7.52	0.11	845.69	826.28	1352.7	3.850	0.087	0.0171						
23	-8.02	0.11	845.84	826.43	1352.7	3.851	0.087	0.0171						
24	-8.51	0.11	845.89	826.47	1352.7	3.851	0.087	0.0170						
25	-9.01	0.11	845.83	826.42	1352.7	3.851	0.087	0.0170						
26	-9.51	0.11	845.61	826.19	1352.7	3.850	0.087	0.0170						
27	-10.00	0.11	845.61	826.20	1352.7	3.850	0.087	0.0170						
28	-10.99	0.11	845.76	826.35	1352.7	3.850	0.087	0.0171						
29	-11.98	0.11	845.80	826.38	1352.7	3.850	0.087	0.0173						

MODEL FLOWFIELD PHOTOGRAPHS TAKEN AT ALPHA = 20.34, 15.06, 9.98, 5.00, -0.10, -3.96,

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HMO/SEI MAT I FORCE TEST
PAGE 2

DATE COMPUTED [illegible]
TIME COMPUTED 09:[illegible]
DATE RECORDED 20-JUL-[illegible]
TIME RECORDED 10: [illegible]
PROJECT NUMBER V4[illegible]

TABLE A-7. FORCE AND MOMENT DATA (CONT'D)

RUN	CODE	M	PT	TT	Q	P	T	RE	A	REF LENGTHS(CLM,CLN,CLL)		
17	7	7.97	826.46	1352.7	3.851	0.087	98.6	0.360E+07	75.784	33.258	33.258	33.258

CONFIG	PNOSE	SLICES	FLAP	TRIP
10.5/7 BICONIC	0.5	DOUBLE	10	60M

--- BODY AXES ---

PN	ALPHA	BETA	PHI	CN	CLM	CLMF	CY	CLN	CLL	CAT	CAB	CA	NCP/LM	XCP/LM
1	20.00	0.03	0.09	0.7707	-0.5029	-0.5030	-0.0062	0.0040	0.0001	0.1790	0.0139	0.1651	0.6525	0.6533
2	19.00	0.03	0.09	0.7226	-0.4708	-0.4710	-0.0054	0.0035	0.0001	0.1713	0.0151	0.1562	0.6516	0.6502
3	18.00	0.03	0.09	0.6766	-0.4403	-0.4405	-0.0052	0.0034	0.0001	0.1643	0.0159	0.1484	0.6508	0.6499
4	17.00	0.03	0.10	0.6318	-0.4106	-0.4108	-0.0049	0.0032	0.0001	0.1573	0.0165	0.1408	0.6499	0.6530
5	16.00	0.03	0.09	0.5678	-0.3815	-0.3817	-0.0047	0.0031	0.0000	0.1506	0.0169	0.1337	0.6490	0.6551
6	15.00	0.03	0.10	0.5446	-0.3530	-0.3531	-0.0046	0.0030	0.0000	0.1441	0.0172	0.1269	0.6481	0.6537
7	14.00	0.02	0.10	0.5024	-0.3252	-0.3254	-0.0044	0.0029	0.0000	0.1377	0.0174	0.1204	0.6473	0.6585
8	13.00	0.02	0.10	0.4617	-0.2985	-0.2987	-0.0045	0.0030	0.0000	0.1318	0.0175	0.1143	0.6464	0.6624
9	12.00	0.02	0.10	0.4213	-0.2720	-0.2722	-0.0039	0.0026	0.0000	0.1258	0.0175	0.1082	0.6456	0.6622
10	11.00	0.02	0.10	0.3821	-0.2464	-0.2466	-0.0034	0.0022	0.0000	0.1204	0.0176	0.1028	0.6448	0.6598
11	10.00	0.02	0.10	0.3434	-0.2212	-0.2214	-0.0029	0.0019	0.0000	0.1151	0.0176	0.0975	0.6441	0.6591
12	9.00	0.01	0.10	0.3054	-0.1965	-0.1967	-0.0027	0.0018	0.0000	0.1099	0.0176	0.0923	0.6433	0.6609
13	8.00	0.01	0.11	0.2659	-0.1707	-0.1709	-0.0013	0.0009	0.0000	0.1019	0.0176	0.0873	0.6422	0.7068
14	7.00	0.01	0.10	0.2279	-0.1460	-0.1462	-0.0006	0.0005	0.0000	0.1001	0.0176	0.0825	0.6408	
15	6.00	0.01	0.10	0.1919	-0.1226	-0.1228	0.0003	-0.0001	0.0000	0.0962	0.0176	0.0786	0.6390	
16	5.00	0.01	0.10	0.1568	-0.0999	-0.1000	0.0006	-0.0003	0.0000	0.0925	0.0175	0.0750	0.6369	
17	4.00	0.01	0.11	0.1231	-0.0781	-0.0783	0.0005	-0.0003	0.0000	0.0895	0.0175	0.0720	0.6345	
18	3.00	0.00	0.11	0.0911	-0.0574	-0.0576	0.0004	-0.0002	0.0000	0.0870	0.0174	0.0697	0.6299	
19	2.00	0.00	0.11	0.0596	-0.0370	-0.0372	0.0002	-0.0001	0.0000	0.0852	0.0173	0.0679	0.6202	
20	1.50	0.00	0.11	0.0440	-0.0269	-0.0270	0.0002	-0.0001	0.0000	0.0844	0.0172	0.0672	0.6099	
21	1.00	-0.00	0.11	0.0284	-0.0167	-0.0168	0.0002	-0.0001	0.0000	0.0839	0.0172	0.0668	0.5873	
22	0.50	-0.00	0.11	0.0123	-0.0062	-0.0064	0.0002	-0.0000	0.0000	0.0836	0.0171	0.0665	0.5045	
23	0.00	-0.00	0.11	-0.0034	0.0040	0.0038	0.0001	-0.0000	0.0000	0.0836	0.0171	0.0665		
24	-0.50	-0.00	0.11	-0.0190	0.0142	0.0140	0.0001	-0.0000	0.0000	0.0837	0.0170	0.0667	0.7477	
25	-1.00	-0.00	0.11	-0.0347	0.0244	0.0242	0.0000	0.0000	0.0000	0.0838	0.0170	0.0668	0.7034	
26	-1.50	-0.01	0.11	-0.0501	0.0344	0.0342	-0.0000	0.0001	0.0000	0.0843	0.0170	0.0673	0.6862	
27	-2.00	-0.01	0.11	-0.0657	0.0445	0.0443	-0.0002	0.0002	0.0000	0.0851	0.0170	0.0661	0.6766	
28	-3.00	-0.01	0.11	-0.0975	0.0649	0.0647	-0.0002	0.0002	0.0000	0.0870	0.0171	0.0699	0.6653	
29	-4.00	-0.01	0.11	-0.1298	0.0655	0.0853	-0.0003	0.0003	0.0000	0.0897	0.0173	0.0724	0.6584	

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PAGE 3

DATE COMPUTED 27-JUL-81
TIME COMPUTED 09:49:16
DATE RECORDED 20-JUL-81
TIME RECORDED 10: 5:39
PROJECT NUMBER V43B-21

TABLE A-7. FORCE AND MOMENT DATA (CONT'D)

RUN	CODE	M	PT	TT	Q	P	T	RE	A	REF LENGTHS(CLM,CLN,CLL)		
17	7	7.97	826.46	1352.7	3.851	0.087	98.6	0.360E+07	75.784	33.258	33.258	33.258

CONFIG	RNOSE	SLICES	FLAP	TRIP
10.5/7 BICONIC	0.5	DOUBLE	10	60M

--- WIND AXES ---

PN	ALPHA	BETA	PHI	CLN	CLMW	CCW	CLNW	CLLW	CDW	(L/D)W
1	20.00	0.03	0.09	0.6678	-0.5030	-0.0059	0.0038	0.0011	0.4187	1.5948
2	19.00	0.03	0.09	0.6323	-0.4710	-0.0052	0.0033	0.0009	0.3829	1.6513
3	18.00	0.03	0.09	0.5976	-0.4405	-0.0050	0.0032	0.0009	0.3502	1.7066
4	17.00	0.03	0.10	0.5630	-0.4108	-0.0048	0.0031	0.0008	0.3194	1.7628
5	16.00	0.03	0.09	0.5282	-0.3817	-0.0046	0.0029	0.0007	0.2905	1.8179
6	15.00	0.03	0.10	0.4932	-0.3531	-0.0045	0.0029	0.0007	0.2635	1.8715
7	14.00	0.02	0.10	0.4584	-0.3254	-0.0043	0.0028	0.0006	0.2383	1.9233
8	13.00	0.02	0.10	0.4242	-0.2987	-0.0044	0.0029	0.0006	0.2152	1.9708
9	12.00	0.02	0.10	0.3896	-0.2722	-0.0039	0.0025	0.0005	0.1935	2.0139
10	11.00	0.02	0.10	0.3555	-0.2466	-0.0033	0.0022	0.0004	0.1738	2.0453
11	10.00	0.02	0.10	0.3212	-0.2214	-0.0029	0.0019	0.0003	0.1556	2.0640
12	9.00	0.01	0.10	0.2872	-0.1967	-0.0026	0.0017	0.0002	0.1390	2.0672
13	8.00	0.01	0.11	0.2511	-0.1709	-0.0013	0.0009	0.0001	0.1234	2.0343
14	7.00	0.01	0.10	0.2161	-0.1462	-0.0005	0.0004	0.0000	0.1096	1.9710
15	6.00	0.01	0.10	0.1827	-0.1228	0.0004	-0.0001	-0.0000	0.0982	1.8593
16	5.00	0.01	0.10	0.1496	-0.1000	0.0006	-0.0003	-0.0000	0.0884	1.6935
17	4.00	0.01	0.11	0.1178	-0.0783	0.0005	-0.0003	-0.0000	0.0805	1.4639
18	3.00	0.00	0.11	0.0873	-0.0576	0.0004	-0.0002	-0.0000	0.0743	1.1747
19	2.00	0.00	0.11	0.0572	-0.0372	0.0002	-0.0001	0.0000	0.0700	0.8180
20	1.50	0.00	0.11	0.0423	-0.0270	0.0002	-0.0001	0.0000	0.0683	0.6188
21	1.00	-0.00	0.11	0.0272	-0.0168	0.0002	-0.0001	0.0000	0.0673	0.4043
22	0.50	-0.00	0.11	0.0117	-0.0064	0.0002	-0.0000	0.0000	0.0666	0.1763
23	0.00	-0.00	0.11	-0.0034	0.0038	0.0001	-0.0000	0.0000	0.0665	-0.0509
24	-0.50	-0.00	0.11	-0.0184	0.0140	0.0001	-0.0000	0.0000	0.0668	-0.2753
25	-1.00	-0.00	0.11	-0.0335	0.0242	0.0000	0.0000	0.0000	0.0674	-0.4971
26	-1.50	-0.01	0.11	-0.0483	0.0342	-0.0000	0.0001	0.0000	0.0686	-0.7048
27	-2.00	-0.01	0.11	-0.0633	0.0443	-0.0002	0.0002	-0.0000	0.0703	-0.9000
28	-3.00	-0.01	0.11	-0.0937	0.0647	-0.0002	0.0002	-0.0000	0.0749	-1.2513
29	-4.00	-0.01	0.11	-0.1245	0.0853	-0.0003	0.0002	-0.0000	0.0813	-1.5313

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
RHO/SFI MAT I FORCE TEST
PAGE 4

TABLE A-7. FORCE AND MOMENT DATA (CONT'D)

DATE COMPUTED 27-JUN-8
TIME COMPUTED 09:49:1
DATE RECORDED 20-JUL-8
TIME RECORDED 10: 5:3
PROJECT NUMBER V438-21

RUN	CODE	M	PT	TT	Q	P	T	RE	A	REF LENGTHS(CLM,CLN,CLL)		
17	7	7.97	826.46	1352.7	3.851	0.087	98.6	0.360E+07	75.784	33.258	33.258	33.258

CONFIG	RNOSE	SLICES	FLAP	TRIP
10.5/7 BICONIC	0.5	DOUBLE	10	60M

-- FLAP DIFFERENTIAL, BODY AXES --

PN	ALPHA	BETA	PHI	DCN	DCLM	DCLMF	DCY	DCLN	DCLL	DCAT
1	20.00	0.03	0.09	0.0948	-0.0925	-0.0925	-0.0006	0.0004	0.0000	0.0253
2	19.00	0.03	0.09	0.0888	-0.0868	-0.0868	-0.0000	0.0000	0.0000	0.0234
3	18.00	0.03	0.09	0.0836	-0.0816	-0.0816	0.0002	-0.0001	0.0000	0.0219
4	17.00	0.03	0.10	0.0790	-0.0769	-0.0769	0.0003	-0.0001	0.0000	0.0205
5	16.00	0.03	0.09	0.0736	-0.0717	-0.0717	0.0003	-0.0002	0.0000	0.0191
6	15.00	0.03	0.10	0.0688	-0.0668	-0.0668	0.0003	-0.0001	0.0000	0.0178
7	14.00	0.02	0.10	0.0640	-0.0620	-0.0620	0.0002	-0.0001	0.0000	0.0166
8	13.00	0.02	0.10	0.0601	-0.0579	-0.0579	-0.0001	0.0001	0.0000	0.0156
9	12.00	0.02	0.10	0.0556	-0.0535	-0.0535	0.0002	-0.0000	0.0000	0.0142
10	11.00	0.02	0.10	0.0516	-0.0495	-0.0495	0.0001	0.0000	0.0000	0.0131
11	10.00	0.02	0.10	0.0478	-0.0457	-0.0457	0.0003	-0.0002	0.0000	0.0120
12	9.00	0.01	0.10	0.0446	-0.0423	-0.0423	0.0000	0.0000	0.0000	0.0110
13	8.00	0.01	0.11	0.0400	-0.0379	-0.0379	0.0003	-0.0001	0.0000	0.0101
14	7.00	0.01	0.10	0.0355	-0.0336	-0.0336	0.0004	-0.0002	0.0000	0.0088
15	6.00	0.01	0.10	0.0313	-0.0295	-0.0295	0.0008	-0.0005	0.0000	0.0078
16	5.00	0.01	0.10	0.0273	-0.0256	-0.0256	0.0010	-0.0006	0.0000	0.0066
17	4.00	0.01	0.11	0.0236	-0.0221	-0.0221	0.0009	-0.0005	0.0000	0.0057
18	3.00	0.00	0.11	0.0207	-0.0191	-0.0191	0.0009	-0.0006	0.0000	0.0048
19	2.00	0.00	0.11	0.0181	-0.0165	-0.0165	0.0008	-0.0005	0.0000	0.0041
20	1.50	0.00	0.11	0.0167	-0.0152	-0.0152	0.0009	-0.0006	0.0000	0.0037
21	1.00	-0.00	0.11	0.0154	-0.0140	-0.0140	0.0009	-0.0006	0.0000	0.0035
22	0.50	-0.00	0.11	0.0140	-0.0127	-0.0127	0.0008	-0.0005	0.0000	0.0031
23	0.00	-0.00	0.11	0.0127	-0.0115	-0.0115	0.0009	-0.0005	0.0000	0.0028
24	-0.50	-0.00	0.11	0.0119	-0.0106	-0.0106	0.0009	-0.0006	0.0000	0.0026
25	-1.00	-0.00	0.11	0.0108	-0.0097	-0.0097	0.0009	-0.0005	0.0000	0.0022
26	-1.50	-0.01	0.11	0.0101	-0.0089	-0.0089	0.0009	-0.0005	0.0000	0.0020
27	-2.00	-0.01	0.11	0.0097	-0.0084	-0.0084	0.0007	-0.0005	0.0000	0.0020
28	-3.00	-0.01	0.11	0.0083	-0.0072	-0.0072	0.0009	-0.0005	-0.0000	0.0016
29	-4.00	-0.01	0.11	0.0076	-0.0065	-0.0065	0.0007	-0.0004	-0.0000	0.0015

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